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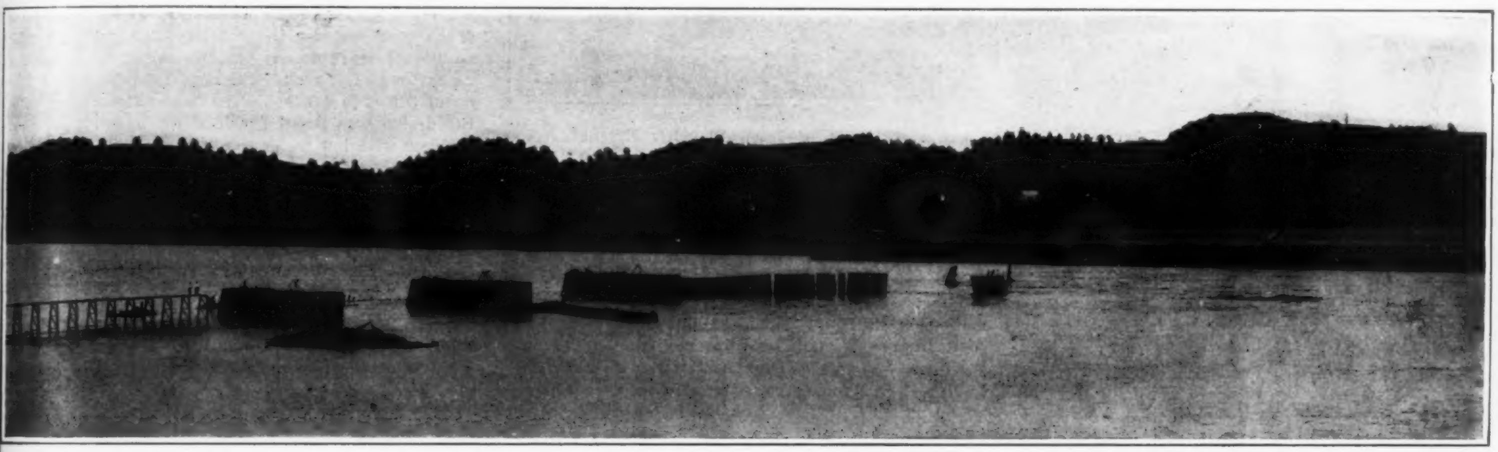
Failure of Navigable Pass Foundation, Ohio River Dam

THE following statement of conditions at Dam 26, Ohio River, where the navigable pass foundation failed on August 8th, 1912, is derived from the records now available. More conclusive data bearing upon the accident will probably be secured when the foundation is unwatered for reconstruction, which will be undertaken at once with the available funds, the unexpended balance of the appropriation for the dam being more than sufficient for this purpose.

The construction of Lock and Dam No. 26, Ohio River, was authorized by Congress in 1907, and five appropriations were made for it in successive years, aggregating a total of $1,200,000. The work was practically completed in 1911. It conforms to the general type in use on the Ohio River. The lock is 110 by 600 feet. The dam is movable, consisting of a navigable pass 600 feet long, 2 bear-traps, each 91 feet, 3 bear-trap piers aggregating 38 feet, and a chanoine weir of 272 feet. The dam was first raised on July 16th, 1912, but the pool was filled only within two feet of the crest, and there was a maximum head of only about 5.8 feet of water. With full pool above the dam and low water below it there would be a maximum head of 14.2 feet. On July 18th the dam was lowered on account of high water, and it was not raised again until August 7th. Beginning at 7:30 A. M., with the stage 4.9 feet above low water, the pass was completely raised by noon, when the gages above and below the dam were 6.5 and 3.7 feet, respectively, above low water. One bear trap was raised at 4 P. M., and the other at 8 P. M. The pass failed at 6:30 A. M., August 8th, 1912, when the upper pool was 0.8 foot below the crest of the dam; the upper pool level being 13.4 feet, and the lower 2.7 feet, above low water, giving a head of 10.7 feet.

According to the eye witnesses, the first movement observed was that of several wickets in the middle part of the river, falling as if dropping to their lowered position on the foundation. Immediately thereafter the wickets on each side began to move downstream, and apparently slightly to the right and left, away from the point of first failure, the failure gradually extending to the river wall and to the bear-trap pier. One hundred and twenty-nine of the wickets remained standing in their vertical position, and the



View Looking Upstream at the Scene of the Failure.

View Showing Wickets After They Had Been Carried Down Stream.

FAILURE OF THE OHIO RIVER DAM.

other twenty-one dropped below the surface of the water. Three of these twenty-one were located afterward in a partly fallen position. Eighteen wickets are as yet unaccounted for, but it is thought they have probably fallen into their lowered positions on the foundation, and that none of them have moved as far downstream as the maximum movement of the wickets which remained standing. One wicket is badly tilted to one side as might happen from the failure of a horse box. The greatest movement downstream was 157 feet, occurring at a point 455 feet from the river wall, measured to one wicket of a group of seven wickets which stand in a position oblique to their original one, the foundation at one side being pushed a little farther downstream than at the other. The final positions of the shifted portions are all shown on the accompanying half-tone illustrations. It will be noticed therefrom that thirty-two wickets next to the bear-trap pier turned about the lower end of the concrete, where it abuts on the pier, and that in doing so the lower monolith of the pier was moved directly downstream about one half inch, the foundations of the bear-trap proper preventing it from moving sidewise. To relieve the current, forty-five wickets next to the river wall were lowered before instructions not to do so were received at the dam, and it has not yet been ascertained if there was any motion downstream of the first 10 or 12 wickets next to the river wall, although the lockmaster feels certain there was little or none. The location of the wickets left standing were accurately determined with the aid of transit observations.

The sections of the dam in moving downstream were raised two or three feet vertically as indicated by the soundings. These soundings when taken over the foundations are the elevation of the surface of the concrete, there being little or no gravel thereon. Soundings were taken to determine if the concrete was turned up or uneven, but it is apparently about horizontal. Soundings were taken with a pole.

A diver was sent to examine the foundations after the failure. It was possible for him to work only in certain localities owing to the current. Starting at a point about 50 feet from the bear-trap pier, he examined the foundation rock, where the pass had been, for about 30 feet toward the lock. Some gravel had washed onto the rock, but in places the diver was able to reach the bottom of the upstream trench. At this point there are two trenches in the rock which had been filled in with the concrete of the foundation. None of the concrete was left in place. Examining downstream from the upper trench the rock seemed to be horizontal on a level with the bottom of the trench, indicating that the rock had sheared off above that elevation. The rock was higher on the upper side of the trench, it being apparently intact. At a point about 180 feet from the river wall, where there was slight motion in the foundation, the upstream face of the foundation was comparatively free from gravel, and the diver was able to examine it for a distance of 30 to 40 feet. He found the concrete intact everywhere to the very bottom, indicating that it had moved as a whole.

View Along Axis of Dam, Showing Extent of Displacement of Wickets.

In building the pass foundation, the surface rock was removed in most places for a depth of about two feet. This material was shale for practically the entire length of the pass, but seemed quite substantial after the top layers were removed. It did not give a ring when struck with a hammer such as hard granite or lime stone gives, but it gave the impression of being solid and firm. The surface layers were loose and a piece of it one half inch thick could easily be broken by the hand, but pieces excavated from a lower level in preparing the rock to receive the concrete could not be so broken. When excavated the shale tended to break in the horizontal layers, but this tendency disappeared in going downward and the excavated material came out in irregular pieces after the surface layers were removed. Borings were made into the foundation rock to test its character, and the excavation was carried down to a depth supposed safe. In every case all loose or laminated material was removed, and the surface of the rock was rough with irregularities several inches deep. In addition there was a shallow trench in the rock nearly everywhere, and in some places two.

The original cost of the navigable pass was $61,001, exclusive of the cost of horses, props and wickets, which was $43,110. The movable parts will apparently be salvaged completely.

The design for the foundation called for a minimum depth of 2 feet for the concrete slab, with as much additional depth at any place as might be required to reach sound bed rock. The actual depths varied from about 3 feet to 4.6 feet. The assumptions upon which the design was based provided for a full pool above the dam with low water below it, and for upward pressures on the base amounting to 50 per cent of those that would result from upper pool head at upstream side and low water head at downstream side, and uniformly varying heads between these limits. The resultant line of pressure fell within the middle third.

All evidence so far available indicates that the concrete and all construction work in and above it were of good quality, and that the character of the bed rock was not as good as was inferred from the borings and observations made during the progress of construction work.

The Bubonic Plague—I*

Its Menace to the United States of America

By Howard D. King, M.D.

The United States to-day is confronted with a problem of momentous import, and one whose very gravity should awaken the entire country, from north to south, east to west, to immediate action—the danger of plague invasion. Plague has manifested itself in Porto Rico, an American possession, and Cuba, an American dependency, two of the principal islands of the West Indies. No longer may we consider it a disease of only the Old World; it is, despite traditional epidemiologic cant, a disease of universal distribution, and as much at home in the Americas as in the Far East.

The idea of plague ever ravaging the Mississippi Valley or sweeping the Atlantic seaboard of this country may be dismissed by some persons as an unfounded fancy. Notwithstanding the preponderance of belief to the contrary, it is my opinion that the sections of the United States above mentioned will yet have that problem for solution.

This is a rather bold and, perhaps, somewhat alarming prophecy, and its fulfillment depends on the attitude which will be adopted by the constituted health authorities of the threatened coastal States and the working forces of the different health organizations of the National Government. Plague on the eastern coast of the United States is, however, already a national health problem, and not a sectional one, as the presence of the disease was regarded when it made its appearance on the Pacific coast. In a measure, the appearance of plague on the Western coast of the United States some years ago, though at all times and in all places the source of the greatest danger, was not then regarded by the country as a source of national danger by reason of the barrier interposed by the Rocky Mountains. The idea of the Rocky Mountains acting as a protective barrier and limiting the diffusion of this disease is an erroneous one and, for obvious reasons, should no longer be given serious consideration.

Owing to the importance of the subject, I believe a brief historical survey of the prevailing pandemic of the disease is not only timely but absolutely necessary to a proper appreciation of future possibilities of the disease.

The fourth pandemic in the world's history began in 1894, and still prevails. From the recognized Chinese endemic center in the southwestern province of Yunnan, bordering on Thibet and Burma, plague spread to many other parts of China and to Formosa and Japan. It reached Bombay in 1896, and from that point spread throughout India, and, notwithstanding its sojourn of sixteen years, it shows little sign of declining. Jedda became infected in 1897, and again in 1899. In 1899 the disease made its appearance in Madagascar and Mauritius. A year later Mecca became infected, and it was also seen early this same year (1900) in the Transvaal, South Africa. Later, during the same year, it was noted among the dock laborers of Oporto, Portugal. The year 1899 has been, to date, the most eventful in the present pandemic of plague, as the disease appeared in widely separated spots and almost all over the world. In 1900 the disease obtained a footing on the western coast of the two Americas. To-day we admit its presence in South America, and at the same time are not overcertain of its absence from the Pacific coast of the United States. It can be readily seen, therefore, that the pandemic of 1894 is still existent, and its ravages not merely unchecked but in reality growing greater daily, as evidenced by the recent outbreaks in Porto Rico and Cuba.

The probable manner and means as to how plague gained a foothold in Porto Rico and Cuba, and what its presence in those countries means to the United States will be described in another part of this article.

It would be well at this juncture to consider some of the epidemiologic characteristics of the pandemic as it exists to-day.

The current pandemic is similar to those of the past in that the disease has advanced along the highways of commerce, save that its present distribution has been principally by sea routes in contradistinction to the overland routes of former ages. It has also demonstrated that plague can exist and become epidemic to the south of the equator and in the western hemisphere. In addition, it has proved that its limits are not necessarily marked by lines of latitude and longitude, nor by isotherms, and that once the infection is imported to any portion of the world it tends to become epidemic there if the local conditions are favorable.

Certain peculiarities of this pandemic are worthy of consideration, presaging, as they do, danger in the future. Principal among these are, first, a marked variation in the susceptibility of individuals, and, second, a like divergency in the malignancy of the disease in certain epidemic areas. These particular characteristics are dependent on certain conditions as yet undetermined, but there is ample evidence of their existence. A third interesting feature is its ease of transmission and great transportability through the medium of indirect, and also direct, infection. Another fact of significance, and, to my mind, the most dangerous, is the tendency of the disease to remain dormant in certain localities, only to recur and recrudesce sporadically. This apparent inability of plague to cause, in one place, a mighty epidemic, yet displaying also very extraordinary powers of recrudescence and exhibiting marked resistance to all known prophylactic measures, is highly dangerous, as it not unnaturally breeds contempt and inspires disregard as to the real latent force of the disease. To illustrate: The number of cases does not reach a stage when the situation might be termed really alarming. This fact, coupled with slow advancement and a low death-rate, accustoms the people to its presence, and the civic and health authorities are lulled in to a sense of false security, and eventually come to regard it as a disease that can be kept within bounds without very strenuous efforts. During this period the disease insidiously implants itself

* Studies from the Laboratory of Tropical Medicine and Hygiene under the direction of Creighton Wellman, Tulane University of Louisiana, published in the *Journal of the American Medical Association*, July 27th, 1912.

over different parts of the country, establishing numerous foci of infection, only awaiting what may be termed the igniting spark for a monster explosion. In short, such are the peculiar characteristics of the present pandemic, which may later mean so much to us, and nowhere are these characteristics more vividly displayed than in South America. At the present time South America must be considered as the occidental distributing center of the disease.

It may be asked now, where is the source of our danger? Is our health imperiled from without or within? Is our danger close or distant? In answer to the first, as well as the second and third queries, our danger is without, and not within our borders, and it is not distant but very close and really on top of us. The idea of our danger being a national one first received utterance from Dr. Donald H. Currie of the United States Public Health and Marine-Hospital Service, when he prophetically said: "The Mississippi valley might some day be infected with plague as a result of infected squirrels." Shortly after Dr. Currie's foreboding, Dr. Creighton Wellman, Director of the Department of Tropical Medicine of the Tulane University of Louisiana, made a similar prediction and explained in detail how certain breeds of ground animals had a biologic range from California into Alabama. Some months later, Dr. William H. Seemann, Professor of Tropical Diseases in the New Orleans Polyclinic, in a discussion relative to plague invasion, directed attention to the fact that freight trains of the various transcontinental and western trunk lines might during the grain-export season carry infected rats to the shipping points of the Atlantic and the Gulf. To a certain degree the conclusions of these keen observers are correct, but if the Mississippi valley or the central or eastern borders of this country are ever infected or should there occur a wholesale diffusion throughout the United States, irrespective of geographic limitations, the cause, I believe, will be through some port of the South Atlantic or Mexican Gulf; and more than probable the gateway of the infection will be New Orleans, Mobile or Galveston, in the order named. This matter will be considered fully in a later paragraph. Many believe that our only source of danger from without lies in direct communication with the now infected ports of the Far East—India, China and Japan—and that the probability will also be considerably heightened on the completion of the Panama canal. That there is danger from these sources is not denied, but this is not our single source of danger. Our menace to-day, this very moment, is South America, the West Indies, Central America and Mexico. It is the existing infection in the American tropics which threatens our safety, and it behooves us to exercise the greatest caution in repelling the invasion of this traveling disease. The presence of plague in any one of the ports of the South Atlantic or the Gulf of Mexico would imperil the entire country. Thus, to-day we stand facing a problem the solution of which cannot in prudence be undertaken too early.

Let us review conditions as they actually exist.

The entire western coast line of South America is now infected. True, it only lies smoldering, awaiting the spark for a terrible explosion. On the eastern coast the infection is distributed in spots and does not follow a continuous line. How soon these spots may be connected in a chain of continuous infection we do not know. We do know, however, that from one of these infected spots plague traveled to Porto Rico and Cuba.

As to precise conditions prevailing in South America we are, in a measure uninformed, and this lack of knowledge constitutes an element of danger that cannot be overestimated.

In not one of these South American countries does there exist a properly constituted board of health as we understand such bodies. In addition, no reliable certification and recordation of deaths is enforced. Governmental authority relating to health measures is divided in such a manner as to render the service inefficient and confusing. The authorities apparently have not the constitutional power to enact or, at least, enforce such regulations as would tend to lessen the spread of disease and increase professional knowledge on the subject. In some cases there also prevails an appearance of great indifference as to whether or not disease exists.

There is a lack of coöperation between the State and local health officials of South America, and this lack of unity is greatly in evidence during the time of epidemics. Maritime sanitation by the health authorities of these countries is not only improperly conducted, but is, as well, a hindrance to commerce and a source of expense to ship-owners. A uniform international system of maritime sanitation and fumigation would prove of great benefit to shipping, and at the same time minimize the dangers of spread of the disease. The measures used in combating the plague are inadequate and antiquated.

As to the original source of infection on the western coast of South America but little is definitely known, though it is believed that commercial intercourse with India during the early days of the current pandemic is responsible for its presence. Some authorities are of the opinion that the infection might have been received from either Santos, Rio Janeiro or San Francisco. Shipping, both coastwise and foreign, is improperly supervised, and there are grave possibilities of the disease being brought unrecognized aboard ships.

When we consider the disseminative agencies of the disease, the character of the exports of these countries should also receive attention. The exports are hay, wool (vicuna, alpaca and sheep), dry salt hides, chinchilla (rodent) pelts, vegetables, wines, nitrates, copper and silver. In view of the great loss of life as suffered by China in the Manchurian district through trafficking in the pelts of infected marmots, it behooves us to exercise the greatest care in dealing with importations of chinchilla (rodent) pelts.

A study of the types of the peoples on this infected coast offers sufficient explanation for the non-eradication of the disease. Social and economic conditions are not much better than those of the Far East. The educational and intellectual condition of the people is of a low order. This state of affairs may be attributed, in part, to the deadening and debasing effects of centuries of brutal bondage and political vicissitude. The most distinguishing trait in their character is their imperturbable and incurable apathy. They are habitually slow in their movements and extremely indolent. They are timid, shy, secretive and superstitious. The policy of secrecy and denial is peculiar to tropical people, and nowhere is it better exemplified than in the South American. The love of intoxicating liquors is deeply rooted in their nature. Their dwelling places are nothing more than dark, ill-ventilated, one-story thatched huts, offering no defense from either wind or rain. One small room usually shelters the whole family; their bed is a sheep skin or two; their cooking facilities, one or two earthen pots and a rude oven built into the wall; their diet consists mainly of vegetables and corn products.

This is the state of affairs that exists on the eastern and western coasts of South America, but, fortunately, in the latter case, in a modified degree, owing to the civilizing and refining influences of European colonization. It need hardly be added that these remarks do not apply to capital cities such as Buenos Aires, Rio Janeiro and Valparaiso.

Next to be considered will be the relations enjoyed by the coastal cities and towns of South America with the West Indies. In this connection it might be interesting to speculate as to how plague really did reach Porto Rico and, later, Cuba.

It will be remembered that as far back as 1908 the Porto Rican authorities appealed to the Federal Government to protect the islands of Vieuques and Culebra, as they feared those islands would become infected through the bands of smugglers operating in this vicinity. Throughout the West Indies there exists what is known as a restricted or local coastal trade. This coastal trade, which is carried on principally by schooners and sailing vessels of light draft, has within the last few years outgrown its local character, and to-day this trade is carried on between the various islands. Between the larger islands there are intervening groups or rather a chain of very small islands, principally the Bahamas and the Lesser Antilles, and much trading is also carried on between these as well as the larger ones. On account of the very character of the trade, together with the type of vessels engaged therein and the lawless crews which man them, it is a matter of great difficulty to impose successfully the necessary health and quarantine regulations which are so essential in the prevention of disease importation. In fact, these craft, together with the crews employed, are a law unto themselves, and even the regulations which ordinarily govern things maritime hold no terrors for them. These small vessels, many of which are engaged in smuggling operations, ply between the different islands, touching, principally, at small coast towns—places where they are free from the scrutiny of the law and not subject to the restriction of quarantine and health measures. Whence these craft come and whither they go is the *crux* of the whole matter. In this form of contraband trading and commerce will probably be found the cause of plague introduction into Porto Rico and Cuba, the two largest islands of the West Indies. It is well known that a number of these craft make a regular business of carrying home the discharged or dissatisfied laborers of the Panama Canal. A certain percentage of the black labor employed in the digging of the canal, unable to stand the disciplinary measures of organization and influenced by inherent indolence, are continually being released. When we consider the roaming spirit of this class of people, who, after leaving the Canal Zone, wander aimlessly about the South American coast, minus the strong hand of their former health organization, it is small wonder that plague ingrafted itself on Porto Rican and Cuban soil. Many of these roving laborers, through their love of adventure, prompted by past experiences, seek new fields, and their ultimate goal in the majority of cases is the South American coast.

It will be remembered that, at the outset, attention was called to the existence of plague in spots on the eastern coast of South America, and how that country is regarded at the present time as the occidental distributing center of the disease. It is not only possible, but highly probable that the unlicensed trading and commercial relations of South American coast towns with the West Indies is responsible for plague leaving the mainland and appearing in the West Indies. Epidemiologists have expressed surprise that Porto Rico should have become infected with plague, owing to the efficiency of the health administration under American auspices. Through the able efforts of the Medical Department of the United States Army, Porto Rico approached the nearly ideal condition from a point of view of sanitation and cleanliness, and yet despite all precaution plague surreptitiously entered and remained concealed until the number of deaths converted doubt and suspicion into reality of their worst fears. It was plague.

The efficiency of the United States Public Health and Marine Hospital Service and the Medical Department of the United States Army might be suggested in refutation of these statements, but the vigilance of these two organizations, together with the modern methods of maritime sanitation and fumigation and quarantine, is not in itself sufficient to prevent plague from being distributed throughout the West Indies, Central America, Mexico and eventually the United States.

Time certainly has not erased from memory the case of plague last January, which escaped detection for two days in Ancon, Canal Zone, the true nature of the disease being revealed only at autopsy in the Ancon hospital. Thus, we see with what ease plague made its appearance in the Canal Zone, where the best health organization in the world is acknowledge to reign. What untold damage one case of plague can do is only conjecturable. What connection this case of plague of six months ago in Panama had with the appearance of the disease in either Porto Rico or Cuba we are unable to state. If one case escaped detection, it is not possible for the same condition to repeat itself?

Despite the most extreme measures, in many instances plague has escaped detection at the hands of health officials and within a very short time assumed epidemic proportions. Granted that every facility be provided for the exclusion of plague, the impracticability of absolute prevention must, owing to the peculiar mode of transmission, appear evident.

Are these the only conditions favorable to the diffusion of plague throughout the American tropics? No! Decidedly, no!

The unstable condition of many of the Central American republics with the added evils of an ever changing political situation, together with constant revolutionary strife, is a permanent danger. The frequency of revolutions of our South and Central American neighbors has given a decided impetus to the illicit schooner coastal traffic previously mentioned, and herein lies one of the greatest dangers. Again, just the same as in South America, cognizance must be taken of social and hygienic conditions in these islands—such as the preponderance of the black race, the percentage of illiteracy, the rate of illegitimacy, the rates of morbidity and mortality, and all the accompanying conditions that an almost submerged people bear. In discussing the appearance of plague in Cuba, sight must not be lost of the close and almost unrestricted relations that exist between the southern Floridian coasts and that island.

(To be continued.)

Our Sense of Hearing

The human ear can hear and distinguish tones ranging through nearly ten octaves: from 16 complete vibrations to 16,384 per second. The middle C has 512 vibrations per second; and the highest note with 16,384 vibrations, is the fifth C above the staff. The lowest possible tone that we can well distinguish is produced by about twenty vibrations. There are many who cannot hear the lower tones mentioned, and some to whom the upper tones are a myth.

The complete range is shown by the following scale:

Of these tones the ordinary orchestras use those from 32 to 4,096 vibrations, inclusive (denoted by quarter-notes in the accompanying diagram).


The Loven Glacier at King's Bay, Spitzbergen, With Its Terminal Moraine.

The Airship as an Adjunct in Geophysical Studies

Landscape Features Disclosed in Bird's Eye View

THE practical value of both spherical and dirigible balloons in meteorological investigation, has been strikingly demonstrated, and its appreciation is attested by the construction on the new Zeppelin "airliner," the "Schwaben," of a completely equipped laboratory for the study of such questions, as has already been described in the pages of the SCIENTIFIC AMERICAN.

But meteorology is by no means the only science in which superterrestrial observations are of value. Such observations and their photographic records are being found of invaluable importance in the study of various geographic and geophysical problems. Definite results have already been obtained and others are confidently hoped for in this province, including aerology and aerodynamics, the hydrodynamics of terrestrial masses of water, oceanography in general, coast formation and erosion, glacial and volcanic modifications of the earth, river and lake phenomena, etc.

The practical arts of navigation and of map and chart making are likewise the gainers thereby.

Various investigators have been working along these lines, but doubtless the most enthusiastic, as well as the most eminent of them all is Prof. Hugo Hergesell of Strassburg. The marvelous achievements of Count Zeppelin, would indeed, have hardly been possible, but for the able co-operation of Dr. Hergesell and the profound and extensive scientific knowledge, which he has put at the service of the inventor. The two have been and still are, intimately associated. They shared the intoxicating triumph of that memorable day in 1907, the thirtieth of September, when the first extended flight of the first Zeppelin dirigible was accomplished, and they went together to Spitzbergen, on the preliminary trip having the study of arctic conditions for its goal.

In a late number of *Petermann's Mitteilungen*, Prof. Hergesell publishes a long article upon this subject, accompanied by the very remarkable pictures, taken on Lake Constance and in Spitzbergen, which we reproduce herewith.

The accompanying view of a steamer on Lake Constance was taken on the flight above referred to, of September 30th, 1907.

It shows with wonderful clearness the wave systems, accompanying the passage of the ship. It is now recognized that the study of such wave systems is of great importance, both theoretically and as a matter of navigation, because of the effects on resistance, speed, and fuel consumption of ships. Of late years, many scientists have worked along this line, including such men, as Lord Kelvin, R. E. Froude, and W. V. Ekman. A method of study has been laboratory work by means of small models in tubs, but obviously the observation of large vessels under actual conditions is vastly superior. Consequently, photographs of attendant waves have been taken on board the vessel, but a serious disadvantage here is found in the fact, that the crest of the wave cuts off from view the immediately following aspects. The photographic view from above obviates this difficulty.

"Both at the bow and the stern," writes Prof. Hergesell apropos of this subject, "there are local disturbances of pressure in the upper surface of the water, which are carried forward through the fluid, by the motion of the boat itself. Both centers of disturbance give rise to waves, which we must designate as *constant* in regard to the motion of the boat, and which, therefore, traverse the water at the same speed as does the boat.

"According to theory two wave systems arise, one diverging at an angle from the ship and the other nearly perpendicular to the axis of motion.

"The accompanying photogram represents very clearly the waves of the forward motion of the boat. We perceive accurately the first wave system, diverging

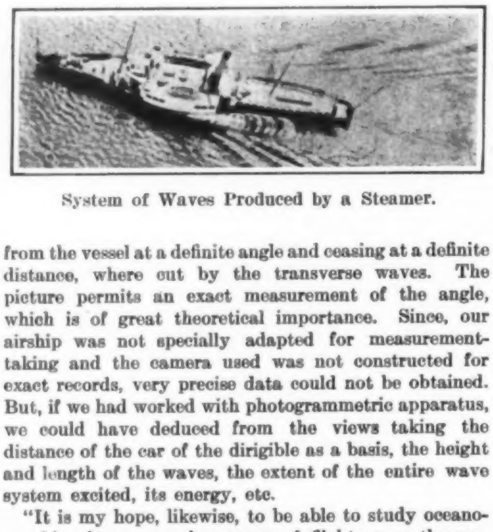
System of Waves Produced by a Steamer.

from the vessel at a definite angle and ceasing at a definite distance, where cut by the transverse waves. The picture permits an exact measurement of the angle, which is of great theoretical importance. Since, our airship was not specially adapted for measurement-taking and the camera used was not constructed for exact records, very precise data could not be obtained. But, if we had worked with photogrammetric apparatus, we could have deduced from the views taking the distance of the car of the dirigible as a basis, the height and length of the waves, the extent of the entire wave system excited, its energy, etc.

"It is my hope, likewise, to be able to study oceanographic phenomena, by means of flights over the sea. There can be no doubt, that exact photographs of the surface of the sea will enable us better to understand, not only wave forms, but other phenomena of surface motion.

"Ocean currents can be followed for great distances, especially at their borders, as well as breakers, certain deep sea conditions, and so forth."

The illustration below, of Lake Constance, is of interest, because of the information it presents at a glance of the deeps and shallows along the shore. It was taken only last year during a flight made at a height of



Lake Constance. Note the Shoals Around the Coast Line.

a thousand meters above the lake (consequently 1,400 meters above sea-level), by Capt. A. D. Wilcke, at that time engineer at the Zeppelin works.

It shows the Island of Mainan with the surrounding water and adjacent coast line, and indicates immediately how admirably comparative depth can be determined by an overhead view, through differences in light and shade.

It is a well-known fact, that in many lakes, as well as in Lake Constance, the basin has the characteristic feature of a second beach or ledge above deep water, but below the ordinary water line. From the upper beach a steep slope, which is often dry in periods of low water, leads to a flat ledge of varying width; from this there is apt to be an abrupt drop to deep water. Our picture shows at a glance the course of this ledge. It runs at an easily perceptible distance of 10 to 20 meters parallel to the main bank. That its water depth is insignificant is shown by the fact, that steamship piers are generally extended to its outer edge, except in a few instances, where it is dredged out.

The greatest depth of the ledge shown in our photograph, is a trifle over 3 meters, which is the usual depth on this flat terrace surrounding Lake Constance.

Our picture shows other noteworthy peculiarities. Thus it is seen, that the Island of Mainan is separated by a narrow shoal from the mainland, so that from above it looks more like a peninsula than an island.

This view was taken by a simple apparatus, without a photogrammetric device, but it could easily be used for map-making by indentifying four points in it with corresponding points on a map drawn to scale, and applying the familiar law of Möbius.

For map-making and chart-making in general, especially over unknown country, or country offering difficulties to foot travel, the taking of exact photographs, or photograms from dirigibles offers very obvious advantages, especially in the saving of time and expense. In this work great accuracy is of course necessary, and two or three methods of insuring this have been worked out. One of the best of these was originated and elaborated by the lately deceased Austrian soldier, Capt. Scheimpflug of Vienna. He worked with the so-called panorama-apparatus, consisting of a central camera and a circle of surrounding cameras fastened to this and fixed at definite angles in relation to it. This forms a "precision instrument" by means of which angle measurements may be taken to an exactness of 20 seconds. In use the optical axis of the apparatus must be vertical, the plate of the middle camera being horizontal. The photograph gives a polygon, whose diameter is about 5 times the height at 300 meters relative height, accordingly, a territory of about 2 square kilometers is covered, and at a thousand meters height an extent of 20 square kilometers is covered.

By a special transforming apparatus, the lateral pictures are reduced to the plane of the middle picture and then, by another device especially constructed by Scheimpflug, all are united into a single picture. The horizontal birds-eye view thus obtained, is when necessary reduced to scale and transformed into a true orthogonal projection.

This method is commended by Prof. Hergesell, but he strongly advises that it should be used in conjunction with another mode of procedure, both to supplement it and to act as a control. This he defines as the application of stereophotogrammetry to measurement from a birds-eye view.

"It is an easy matter," he says, "in a Zeppelin dirigible

View on the South Coast of King's Bay, Showing Lagoons.

Promonotory on the West Coast of King's Bay.

to set up two sets of photographic apparatus which shall be rigid and have parallel optic axes, and which shall be far enough apart to allow them to be operated at a sufficiently great distance from the surface of the earth. In the Zeppelin's now in use, photographs to scale can be conveniently taken with a ground-line of over 100 meters in length.

"Every stereoscopic photograph made on the airship presents, therefore, in itself a triangulation with a base measure, and can thus serve as the starting point for further measurements. There are, to be sure, small difficulties to be overcome. The base which the airship carries about with it will usually not be exactly horizontal, but there is nothing to prevent us from measuring the angle of deviation for every snapshot, and reducing the photogram to the horizontal.

"Views of extended unknown territory, can in this manner be obtained from the Zeppelin's without the necessity of a synchronous triangulation of the surface of the earth.

"For the measurement of unknown regions, I commend the combination of these two methods—the stereophotogrammetric and the horizontal panoramic view proposed by Scheimpflug."

The remaining pictures shown in the article were all taken in Spitzbergen from a captive balloon. They all show with extraordinary beauty and vividness views of King's bay and the surrounding land.

The striking feature of the latter is the glacier formation with the accompanying streams and moraines. The coast-line presents an equally remarkable aspect, being notched by triangular promontories and bays into a series of sharp points.

The significance of such phenomena to the geologist and the geophysicist is at once obvious. Every one of these views sets an interesting problem to be solved by a careful study of all and comparison with similar territories in better known regions.

According to Drygalski, an authority on the subject, such a formation of the coast, with its geometric triangulation, is characteristic of land bordered by retreating glacier systems. Such systems discharge vast quantities of mud and rubbish which move slowly downward in a viscous and sluggish, but irresistible torrent and force their way between the rocky boundaries in the shape of tongues and triangles of land.

After discussing the Spitzbergen conformation and the explanation thereof at much length, Prof. Hergesell especially directs attention to the fact of the enormous saving in time and energy, not to mention food and other supplies, effected by this mode of geographic study.

"More than ten such views were obtained," he says, "in a short ascent of 10 minutes. The complete ascent, including the filling of the balloons, and so forth, occupied only a part of a single afternoon. How much more could have been accomplished if we had really undertaken a cartographic exploration of the country with specially constructed apparatus, above all, if a dirigible, capable of changing its locality at will, had been at our disposal."

It is probable that the methods of scientific investigation by photographs from balloons as above outlined will be very widely applied in the near future, especially in the German colonies, and results of much importance will certainly be obtained.

Another observation made by Hergesell in flying at comparatively low altitudes belongs the field of aerodynamics. He found that the air pressure was affected in the lower layers of the atmosphere by the conformation of the land.

He noted in the trip of 1907, over Lake Constance already mentioned, that vertical currents were to be distinguished on the windward and leeward sides of every hill. Though he did not then attempt to measure them, he was confident this could easily be done with proper registering instruments. He found, too, that their influence could be avoided by the simple expedient of rising above the layers affected.

The Eighth International Congress of Applied Chemistry—II

A Survey of Some of the Principal Papers Presented

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 1916, Page 183, September 21, 1912

VIII d. BIOCHEMISTRY, INCLUDING PHARMACOLOGY.

A large number of papers have been submitted under this section and only a few can be mentioned here.

E. D. Clark makes a communication on the subject: *The Origin and Significance of Starch,* in which he discusses the physical and chemical nature of starch, its significance to plants, to man and to animals, and also its industrial importance.

An interesting subject is taken up by M. A. Crillat, namely, *Influence of Gaseous Impurities in the Air on the Vitality of Microbes.* He finds that the presence of certain gases is an important factor in determining the development of microbes.

The question of sulphurous acids in white wines, regarding which we noted a paper in the Section of VIb, "Fermentation," is taken up in this section also by P. Malvezin.

SECTION IX IS DEVOTED TO PHOTOCHEMISTRY.

On looking over the index one is struck with the large list of contributions from the Department of Physical Chemistry of Cornell University, under the name of Prof. Wilder D. Bancroft, who, it should be mentioned, has contributed to other volumes beside this. In this section he deals with the subjects of *Chemiluminescence; The Chemical Action of Light; The Double Spectrum of Sodiumchloride; The Effect of Potassium-bromide in Retarding the Action of Photographic Developers; The Latent Image* (of the photographic plate); *The Permanency of Paintings; The Photochemical Oxidation of Benzene; The Silver Equivalent of Hydroquinone; Rapid Testing of Dyes and Pigments; The Second Positive.*

An interesting point is brought out by C. W. Bennett, who shows that light favors the reduction of ammoniacal solutions of coppersulphate.

Another interesting paper from Cornell University is one by Farnau and Lohr, who have applied the methods of color photography to the investigation of the phenomenon of luminescence. The colors of luminescence from various sources are generally difficult to describe. It is not a matter of surprise that the color of luminescence in a given case, often very faint, should be a matter of dispute. The spectrograph would solve the difficulty but its use in connection with very faintly luminous sources would obviously be fraught with great difficulties. Prof. Bancroft, therefore, suggested the application of color photography. The authors report very fair success in their efforts, exposures of even five minutes giving plates in which the color is easily discernible as that of the fluoresence.

Messrs. Frary, Mitchell and Baker contribute an interesting paper on *The Direct Production of Positives in the Camera by Means of Thiourea and Its Compounds.* They find that the most important condition for success is a proper control of the temperature of the developer. Double salts of thiourea with ammonium bromide and chloride work better than thiourea itself. The process gives positives in excellent detail with about the gradation and density of a first-class negative. The exposure is relatively short, being about double that required for a normal negative.

We have selected here only a few of the very large number of excellent papers contained in this volume. It is hoped that we may have an opportunity of returning to a more detailed consideration of some of these in later issues of the SUPPLEMENT.

X a. ELECTROCHEMISTRY.

Of the papers presented in this section, special mention should be made of one by R. Amberg on *The Function of Slag in Electric Steel Refining,* and one by Hanson & Lewis on a *Method for Testing the Mutual Corrosive Effect of Metals.* Carl Hering makes a plea for the simplification of calculations by a suitable choice of units, based on the C. G. S. system. P. Heroult contributes a paper on *Recent Developments in the Electric Steel Furnace.* In his introduction he says: "The electric furnace has now reached a point when reduction of costs depends entirely on improvements in detail, both in furnace construction and manipulation. It may be said that the general principles of electric refining have been so clearly established that it is now possible to determine those furnaces which are destined to play an important part in the metallurgy of iron and steel." Again, in another portion of the paper, the author says:

"The progress of electric steel refining has been retarded considerably by the large number of unsuccessful furnaces that have been erected by men who possess no special knowledge of electric furnace work or the steel trade and considerable quantities of inferior steel have been turned out in the past as a result of this. To erect and operate an electric furnace successfully it is essential to have had considerable experience, both in the steel trade in general and in electric furnace work in particular, as the old established principles of steel making cannot always be followed. As progress continues and operating expenses are reduced, a continually widening field for the process and a cheapening of the best qualities of steel will result together with an improvement of the quality of castings and other materials which can be manufactured at a low price.

"Time has also eliminated many difficulties and fallacies relating to electric furnace work, so that it is now easier for the steel maker to decide the type of furnace he should adopt and to undertake the manufacture of electric steel with complete confidence."

E. B. Spear contributes a paper on *The Function of Inorganic Addition Agents in the Electrolytic Deposition of Copper.*

In this article the theory is advanced that the function of inorganic addition agents in the electrolysis of copper solutions is to keep the copper in solution.

The fundamental assumptions are:

That some particles of copper may assume the colloidal form at the moment of giving up their electric charges at the cathode.

That oxidation may take place on the cathode during the passage of the current.

Experimental proof is given to show that copper is continuously dissolved and reprecipitated at the cathode during the electrolysis of copper solutions.

The theory explains the fact that good deposits of copper become bad if the electrolysis is continued too long.

Speaking on *The Present Status of the Development of Large Electric Furnaces*, Dr. R. Taussig says among other things: "The electrification of the iron industry records its greatest success in Sweden and Norway. In Trollhatten, Domnarfvet, Hagfors, Hardanger and Arendal there are in all 25,000 horse-power thus utilized. In these Scandinavian countries the advantages gained by electrification are particularly great, if we remember that one horse-power year represents two tons of fuel. Therefore, in the manufacture of high-grade steel, in which charcoal is used, the cost of the fuel is about $20 for the equivalent of one horse-power year. The price of electric power, on the other hand, is in these countries very considerably less. On an average it may be said that in Sweden a horse-power year can be obtained at $10, and in Norway at $6.25 per year. Thus an electric furnace in Scandinavia has distinct advantages as regards the cost of energy consumed in comparison with the old blast furnace; it has the further advantage of permitting the use of lower quality ore. In the Grondal furnace 20 per cent of slick (ore dust) can be added; and in the Helfenstein furnace as much as 80 per cent. This is particularly important in Norway, inasmuch as most of the ores there are very much inclined to fritter down into powder. The Swedish Government long ago recognized the importance of the electric furnace for the iron industry and has greatly assisted the development of this branch of industry."

D. C. and M. C. Whipple contributed a paper on *Mill Scale as a Cause of the Pitting of Steel Pipes.*

It is the opinion of the authors that their experiments and observations warrant the following general conclusions relative to short-time tests for corrosion, and to the part played in corrosion by mill scale.

1. Accelerated corrosion tests of iron and steel plates made by immersion in strong acid solutions are of little value as indicating the probable corrosion of the metals in water under conditions of actual service.

2. Accelerated tests made in running water by the use of a current of electreity give results that indicate the *manner* in which the plates will probably corrode in service, that is, whether by pitting or by general corrosion.

3. When steel pipe lines fail, they do so by the formation of numerous pits that ultimately form holes and cause leaks. An important factor in the formation of pits, commonly recognized but by no means fully appreciated, is the mill scale.

4. Steel plates that pit badly under the electrolysis test when the scale is left on do not pit after the scale has been removed.

5. A galvanic survey of the mill scale, made by determining the current that will pass through a sensitive galvanometer placed in the circuit of wires that connect the mill scale with the metal beneath, gives results that differ materially for wrought iron and steel, and from which an index of the uniformity of corrosion may be calculated that bears a general relation to the liability of the metals to form pits.

6. The electrolysis tests and the galvanic survey show that wrought iron has a less tendency to pit than steel, and that American ingot iron is intermediate between the two, but resembles steel more nearly than it does wrought iron.

7. Steels containing copper differ but slightly among themselves and from steel that contains no copper, in their tendency to form pits.

8. To protect steel or ingot iron against failure by pitting, the best remedy is the removal of the mill scale. Efforts should be made to reduce the expense of doing this, or to modify the character of the scale during its manufacture. This appears to be the direction in which future improvements in the manufacture of steel plates for pipe-lines should lie.

M. Wildermann contributes two papers, one on *Recent Progress in the Electrolysis of Alkaline Salts,* the other on a *Process for the Manufacture of Ebonites Capable of Resisting the Action of Alkalis and Chlorine, and Its Effect Upon the Industry of Electrolytic Decomposition of Alkaline Salts.*

X b. PHYSICAL CHEMISTRY.

W. D. Bancroft and T. R. Briggs report on their blue gelatine copper process. This paper was reproduced in detail in our last issue.

R. Beutner reports on *Some Interesting Researches Regarding the Physical Nature of Bioelectric Potential Differences.*

M. A. Colson critically reviews some of the *Fundamental Theories of Physical Chemistry.*

G. K. Burgess reports on the *Present Status of the Temperature Scale.* At the conclusion of his paper Dr. Burgess makes the following recommendations with regard to the establishment of an international temperature scale.

"It is evidently of the greatest importance for chemists and others who have to express or locate many of their results in terms of temperatures, that they be able to do so in terms of a common scale, as otherwise confusion reigns when endeavoring to compare the numerical values assigned by different observers to the various phenomena.

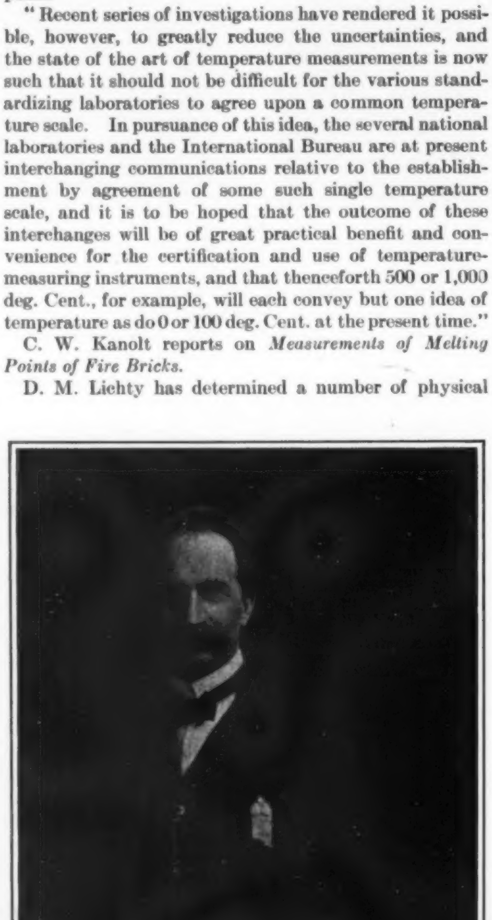
"For the past twenty-five years, thanks to the International Bureau of Weights and Measures, it has been possible to express results to 0.002 deg. Cent. within the fundamental interval 0 to 100 deg. Cent., but outside this interval chaos has reigned.

"Both at low temperatures and high, there have been almost as many scales as observers, and some of the outstanding differences were relatively very large, even within the past year, for example, 1 degree at the sulphur boiling point and 7 degrees at the gold melting point.

"Recent series of investigations have rendered it possible, however, to greatly reduce the uncertainties, and the state of the art of temperature measurements is now such that it should not be difficult for the various standardizing laboratories to agree upon a common temperature scale. In pursuance of this idea, the several national laboratories and the International Bureau are at present interchanging communications relative to the establishment by agreement of some such single temperature scale, and it is to be hoped that the outcome of these interchanges will be of great practical benefit and convenience for the certification and use of temperature-measuring instruments, and that thenceforth 500 or 1,000 deg. Cent., for example, will each convey but one idea of temperature as do 0 or 100 deg. Cent. at the present time."

C. W. Kanolt reports on *Measurements of Melting Points of Fire Bricks.*

D. M. Lichty has determined a number of physical



President of the Next International Chemical Congress

constants of sulphuric trioxide, such as the melting and boiling points, density, coefficient of expansion, and molecular weight. It is to be regretted that this series of determinations does not include the specific heat, which has never been determined, and a knowledge of which would be of interest in connection with the manufacture of sulphuric acid by the contact process.

Prof. A. Reychler contributes a *Study on Soaps.* The last section of this paper is devoted to the mechanism of the detergent action of soap.

Prof. Richard Zsigmondy, famous for his ultramicroscopic researches on colloids, contributes a paper on *A Systematic Classification of Colloids.*

XI a. LAW AND LEGISLATION AFFECTING CHEMICAL INDUSTRY.

This volume contains a number of very interesting papers. The first, by J. Abey, on *The Transportation of Dangerous Goods by Water,* makes the following recommendation:

1. It is desirable that this Congress should appoint an international commission of representatives of the chemical industry, in order to establish, and keep up to date, a list of dangerous goods; to centralize all communications on this subject; to study the special literature; to collect and examine samples; and, perhaps, organize an information service for governments, shipping companies, insurance companies, etc.

2. It is further desirable that this commission should invite to join them authorized representatives of shipping companies.

A. Allart presents a paper on *International Legislation Regarding the Importation of Trade-mark Products,* in which he embodies the following recommendations: "That the use of a trade-mark giving no indication of the origin of the article, on the part of the establishment which imports its products from abroad, be declared permissible, on the one hand in all those cases in which this trade-mark belongs to an exclusively commercial and not manufacturing establishment; on the other hand, in every case in which the said trade-mark conveys no false indication destined to create a false impression in the mind of the buyer."

F. Jacq discusses *Uniform International Legislation for Patents and Trade-marks,* and in another paper deals with the question, *Are International Patents Desirable or Not?* A third contribution is devoted to the subject of the *Obligatory Working of Inventions and Obligatory Licenses.*

E. Delaire discusses the *Preliminary Examination of Patents,* and E. J. McDermott takes up the question of the subject of *Expert Testimony.* The question of the *Patentability of Pharmaceutical Products* is brought before the Congress by A. Taillefer.

XI b. POLITICAL ECONOMY AND CONSERVATION OF NATURAL RESOURCES.

Some of the subjects dealt with here are as follows: *The Chemical Industries of Canada; What the States Are Doing Toward the Conservation and Improvement of Soil Fertility; Research Co-operation, an Experiment in Public Demonstration of Patent Rights; What the Government is Doing in Conservation, Our Anthracite Coal Supply and Its Conservation; Conserving Water Supply; the Relation of the Chemical Industry to the Annual Fire Loss of the United States.*

In conclusion it may not be amiss to say a few words about the retiring president, Dr. W. H. Nichols, who with great skill and tact has guided the Congress from first to last to its most successful issue, and about Prof. Dr. P. Walden, the man who has been selected to fill the same office at the next Congress to assemble in 1915 at St. Petersburg.

Dr. W. H. Nichols is one of the most prominent characters in the American Chemical Industry. He is president of the Nichols Copper Company, one of the greatest firm of copper refiners in the world and of the General Chemical Company, one of the principal manufacturers of heavy chemicals in the Eastern States. Dr. Nichols has not only been eminently successful in the management of large commercial enterprises, but has throughout been a prominent figure in the conduct of the affairs of our chemical societies and institutes.

Prof. Dr. Walden is in some respects a man of different type. He represents the scientific rather than the industrial development of chemistry. As an investigator, he ranks among the very foremost of our contemporaries. His publications number more than two hundred, the most important of them being devoted to the subject of stereo-chemistry, although Prof. Walden has contributed valuable material to other branches of physical chemistry and biochemistry. Special mention should be made also of his biographical memoirs of Bertholot, Pasteur, Mendeléeff and Ostwald.

Prof. Walden is in his fiftieth year. He is a native of Russia, his birthplace being situated in the vicinity of Riga, at which city he received both his early schooling and some of his university education. He also studied and taught for a time at Leipsic University and at Munich. He has been upon the staff of the Polytechnicum at Riga in the capacity of assistant, assistant professor and full professor, and is at the present time director of this institution. Prof. Walden is a man of far more than ordinary attainments and we have every reason to congratulate the members of the chemical profession upon the choice which has been made for president of the next Congress.

Permanent Writing on Aluminium.—Characters that will not wear off in use can be produced on sheet aluminium, according to *Icehinsche Rundschau,* only by etching, aside from stamping, by means of a press, such as is frequently used in making aluminium signs. According to one method, the aluminium is coated at the desired spot with a melted mixture of 2 parts white wax, 2 parts mastic and 1 part asphalt. The characters are scratched in with a graver and the coated metal is immersed in soda lye until active development of gas takes place. According to a second, simpler method, the characters are formed on the metal by means of a rubber stamp or stick, using chloride of platinum solution. The aluminium is colored black at the desired points. The expensive chloride of platinum may, however, be replaced by the cheaper chloride of antimony, to which some chloride of platinum can be added.

Celestial Motions Considered on the Principle of Relativity*

Velocities of Heavenly Bodies Gaged on a Comparative Scale

By Col. E. E. Markwick, C.B., F.R.A.S.

In astronomical text-books and popular works on the science one frequently, and naturally, meets with references to the enormously swift motions of celestial bodies, as compared with terrestrial experience. We read of the great comet of 1882 "rushing through the part of its orbit closest to the Sun," and the fixed stars are described as in reality "flying through space" at enormous velocities of varying direction and amount. One recalls how, in old schooldays, when "doing globes," the master would ask the question, "How fast is the Earth moving in its orbit?" and the pupil would answer, "Rather more than sixty thousand miles an hour." The first time one heard this it sounded as something startling, but the youthful mind cannot easily apprehend such an enormous speed, and by repetition the fact got to lose its significance. All these statements of high speeds are, of course, true, being based on a solar parallax which is now almost certain to the first decimal, combined with observed motions of the heavenly bodies.

Sir. R. S. Ball, a most lucid expositor of celestial facts and figures, remarks in "The Story of the Heavens," on the motion of the Earth: "It will appear that the earth must actually complete eighteen miles every second. Pause for a moment to think what a velocity of eighteen miles a second really implies. Can we realize a speed so tremendous?" He then goes on to compare the motion of the Earth with that of an express train, traveling at the regulation text-book speed of sixty miles an hour, so that the speed of the train "is not even the one thousandth part of the velocity of the Earth in its orbit." But he continues: "Viewed in another way, the stupendous speed of the Earth does not seem immoderate. The Earth is a mighty globe, so great, indeed, that even when moving at this speed it takes about eight minutes to pass over its own diameter. If a steamer required eight minutes to traverse a distance equal to its own length, its pace would be less than a mile an hour." A figure is given, showing two equal circles joined by a straight line, the distance between the centers being about six times a diameter of the circle. If this represents the Earth at two stages in its path, then "the time required to pass from one position to another is about forty-eight minutes."

The particular point now is to consider some of these enormous, and, to our experience, utterly transcendental speeds, relatively to the size of the moving body, because they then begin to assume a different aspect. A sense of proportion must be brought to bear on the matter, and actual terrestrial motions and dimensions must be more or less kept in their proper sphere when studying the order of motions and dimensions of the solar system as a whole. *Apparent* motions, however, are common to whatever position we are in, or may imagine ourselves to be in. Apparent motion, or, as it may here be termed, angular motion, is the speed at which a body moves across the field of view, irrespective of its distance. If we imagine anyone (call anyone an "ether-man," someone above an "air-man" in powers and qualifications), occupying an isolated position in space, it must still be with this corporeal frame, with a pair of eyes to see, and a celestial object to be seen. The rotation of the ether-man's body round its longer axis still sweeps out a field which is measured by three hundred and sixty degrees for a complete rotation. This conception holds good, even if deprived of the terrestrial horizon.

For the present purpose it seems convenient to fix on some limit of angular speed, below which, at the first glance or so, a body seems to have no motion. It is rather an arbitrary proceeding, but may serve for illustration. Put this limit at a rate of transit of 10 degrees in five minutes of time, or 2 minutes of arc in one second; i. e., three hours for the tour of the whole horizon. With this angular speed, a terrestrial object at one hundred yards distant from the observer would have to move at the rate of two hundred and thirty-one yards per hour; at two hundred yards, four hundred and sixty-two yards per hour; at one mile distant about two and one third miles per hour; and at ten miles distant twenty-three miles per hour. For celestial observation, consider an object moving at a less angular speed than this, as seen with the naked eye, to be devoid of visible motion; if it moves faster, then say it has visible motion.

The angular motions of the planets round the Sun, and of the satellites round their primaries, are, of course, far below the limit just fixed. Seen from the Sun, Mercury moves about 0.17 second in one second, the Earth 0.04 second, Neptune 0.00025 second. Turning to the satellites, the rapid Phobos, with its period of seven hours thirty-nine minutes fourteen seconds, moves 47 seconds in one second. Take, again, the case of a comet moving very close round the Sun. The comet of 1843 is stated to have described the whole of the segment of its orbit North of the plane of the ecliptic, in a little more than two hours. This implies an angular velocity of about 90 seconds per second. All these rates of motion are below, and most far below, the hypothetical limit.

What then, would a view of the solar system reveal to the ether-man, placed in space at a point high above the ecliptic? *Above* the ecliptic is, of course, a *façon de parler*, for there is no up or down, as we use the terms, in celestial matters; what is meant is, on that side of the ecliptic plane in which the north pole of the earth is situated. Let this point be somewhere about twice the diameter of Jupiter's orbit "above" the Sun, so as to open out his orbit and those of the planets within. Imagining our friend gifted with the necessary keenness of vision, at a casual glance the whole of the planets would seem to him to be at rest. There they would be, hung in space, apparently fixed points of light. It would be the same with the several families of satellites, supposing the observer could visit each of the mother planets, and note the outlook thence, as he studied the children of each. With the exception of a few of the satellites he would have to watch some little time before the motions of each system could be detected. Even a few stray comets would appear quite motionless in the inter-planetary spaces. All this is on the proviso that the observer has no telescope, but is watching things with ordinary unaided vision.

The same remarks apply with more force to the stellar system. Here, there is not so much need to move from the earthly point of view, as the Earth is surrounded by the stellar universe in all directions. And what is observed? The configurations of the stars remain practically the same from age to age. For thousands of years the old historic constellations have presented much the same shaped groupings; yet it is certain that every star is in motion, all have their proper motions, moreover, there are streams and classes of motions which individually, and taken absolutely, are of immense magnitude. The real motions of individual stars are known to range from ten miles up to forty or fifty miles per second, and in one case two hundred miles per second. All the while their apparent angular motions are extremely small. The principle of relativity must be borne in mind, and then it is seen that if the movements of the stars are compared with their enormous distances apart, the former are really quite slow and gradual.

Absolute terrestrial movements may, of course, be compared arithmetically with celestial ones, but to really grasp the enormous disparity between them is another matter, seeing we are dealing with speeds beyond our own experience. However, an effort may be made to discuss the case of the Earth's orbital motion, compared with that of an express train, as best representative of each class. Such motions as those of a rifle bullet or projectiles discharged by heavy ordnance, as well as molecular motions connected with light, electricity, and so on, are purposely left out of account. Everyone knows the terrific rush and momentum of a train travelling at 60 miles an hour, as seen from the platform of some country railway station, about 20 feet from the rails. A cloud of steam is first noticed and a distant roar heard, which rapidly increases in intensity. In the course of a few seconds, with a sense of momentum which thrills the spectator, the train, weighing hundreds of tons, dashes by, a wind follows, filling up the vacuum thus caused, and all is over.

Suppose, now, a position is taken up, on a clear day, on some elevated ground, such as the southern spurs of Dartmoor, or the South Downs in Sussex, some miles distant from the railway. From such a point the same express may be watched with a field glass, wending its way along the valleys and over the viaducts of the lower district. How the apparent motion is now reduced! There is the long trail of steam, but by comparison the train seems to crawl along in the distance. It is brought home to one that the sense of motion of a body depends on proximity to it.

This idea is well expressed in the following lines from a poem on the South Downs by Mr. R. Bridges, the reference being to steamships in motion, seen a long distance away.

I climb your crown, and lo! a sight surprising
Of sea in front uprising, steep and wide:
And scattered ships ascending
To heaven, lost in the blending
Of distant blues, where water and sky divide,
Urging their engines against wind and tide,
And all so small and slow,
They seem to be wearily pointing the way they would go.

So much for an example of terrestrial speeds.

Is it now possible to place the ether-man so that he can satisfactorily observe the Earth which moves one thousand times as fast as the express? To begin with, the moving body in this case has a diameter of some eight thousand odd miles, and he must be situated, at the very least, four thousand miles from the center line of the Earth's track, if only to avoid collision, if such can be imagined between an atom of a being and such a vast globe. To get anything approaching a reasonable view of the motion, proportionate, in fact, to the conditions of position at a railway station, he must be placed about twelve thousand miles from the center of the track. But seen from this distance the Earth's motion would seem comparatively slow; for, as Sir R. Ball says, it would take eight minutes to pass over its own diameter, which from the selected point of view would subtend an angle of about thrity-nine degrees. This corresponds to an angular rate of motion, when near the spectator, of about 5 minutes a second. This rate, which is certainly above our limit, is yet not fast, corresponding to a body at one hundred yards distance moving across the field of view at a speed of about one third of a mile per hour. At the first glance the Earth would seem to be moving very slowly, in fact more or less "poised in space." Morally speaking, it is pretty certain that no human being could see such a sight—and live.

So far, motions of revolution only have been considered, but motions of rotation of the planets, although much more rapid, are still below our limit. A person on the Earth's equator, we know, is whirled round, in space, at an absolute speed of over one thousand miles per hour. Yet on account of the smoothness of the motion, and every surrounding object, houses, hills, valleys, ocean, atmosphere and clouds moving together, the speed is not appreciated; it is not even experienced. To try for a sense of it, the ether-man must get away from this terrestrial ball at least ten thousand miles, and then the Earth would at the first glance appear motionless, in the matter of rotation. His success would be no better than in his endeavor to watch the speed of the Earth in its orbit.

Hence it may be inferred that although the motions of the solar system, taken absolutely, quite transcend terrestrial molar motions, yet considered relatively to the dimensions of the system they are not what would be termed rapid—far from it. The angular motion of a body round a center of gravitation is governed by the Keplerian laws; the nearer to the center, the more rapid the motion. But even in the extreme case of a body revolving round the Sun, just skimming its surface, and of a body doing the same round the Earth, the angular speed is slower than the limit fixed on.

There is one class of bodies, of a semi-celestial nature, of which no account has here been taken, and which, perhaps, occupy an intermediate position, in the matter of motion, between the planets and the Earth, viz., meteors. Here we have a comparatively minute object moving through the atmosphere at a planetary rate, or something approaching it. Owing to comparative proximity, the great speed of a meteor can better be appreciated than the motion of bodies enormously farther away. It is far in excess of the limit, the body covering twenty degrees, thirty degrees, or more, of the field of view in a very few seconds. But do we then really grasp the meaning of fifty miles a second, which is the speed of many meteors? If one were really very close to a meteor it could hardly be seen as it passed by, except in the form of a flash of lightning, because its flight is so enormously swift. Yet in the inter-planetary spaces, a swarm of meteors (if their visibility is possible) would at the first glance seem motionless, if viewed from a distance sufficiently great to enable the whole swarm, or ring, to be included in the field of view.

It seems clear, then, that celestial motions take on a different aspect when considered with due regard to the dimensions of the bodies concerned, and the distances which separate them.

* Reproduced from *Knowledge*.

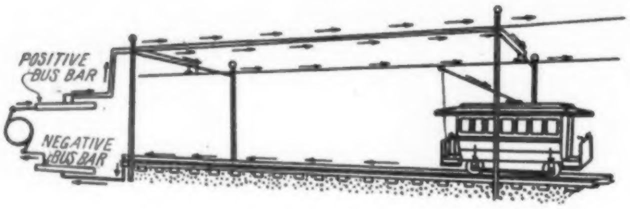


Fig. 1.—Single Trolley Railway, Showing Path of Current from Generator Through Positive Feeders, Trolley Wire, Car and Rails.

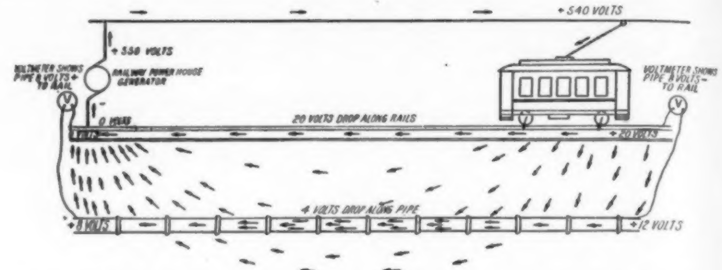


Fig. 2.—Diagram Showing Stray Railway Currents With Assumed Distribution of Potentials Caused by These Currents.

Electrolysis from Stray Currents—II*

Damage Caused to Underground Structures

By Albert F. Ganz, M. E., Professor of Electrical Engineering, Stevens Institute of Technology

Continued from Scientific American Supplement No. 1916, Page 181, September 21, 1912

ELECTROLYSIS SURVEYS.

The diagram illustrated in Fig. 2 shows that voltage drop in the rails produces stray current through ground and through underground pipes, and produces potential differences between pipe and rails, making the pipe appear positive in potential where current leaves the pipe, and negative in potential where current flows to the pipe. The first step in an electrolysis survey of a town is, therefore, to measure potential differences between pipes and rails, at a number of points throughout every street on which there are electric railways. Where the main itself is not exposed, connections to the pipes for these voltmeter measurements may be obtained by means of service pipe or drip connections. Such connections are generally satisfactory because the voltmeter itself has a high resistance and takes only a very small current. Readings are taken at each point every ten seconds for ten or twenty minutes according to the car schedules, and the maximum, minimum, and average results of the readings are recorded. A convenient instrument for these potential readings, which can also be used for the drop measurements described below, is a Weston Model 1 combination millivoltmeter and voltmeter, with its zero in the center of the scale, and having ranges of 5, 50 and 500 millivolts and of 5 and 50 volts. These instruments are made with very high resistances so as to be particularly applicable to electrolysis testing.

After such potential measurements have been made throughout the principal streets of a town, they are then conveniently plotted on a skeleton map of the town, in which the trolley lines are shown. The potentials of the pipes referred to the rails are laid off normal to the lines representing the railway tracks to some convenient scale, usually 1 inch = 10 volts. The ends of these potential lines are then connected, and the included areas are colored red where the pipes are positive in potential to the rails, and blue where the pipes are negative in potential. In Fig. 3 is shown a typical potential survey map, in which the negative areas are shown by dots, and the positive areas by section lines, instead of by blue and red areas. It will be noted that in the neighborhood of the railway power station the pipes are highly positive to the rails, and at points distant from this station they are negative to the rails. The existence of potential differences between pipes and rails is, however, no conclusive evidence of stray currents on the pipes; they indicate at what points current is probably flowing from rails to pipes and from pipes to rails.

The next step in the survey is to measure drop between drip or service connections, which will indicate the probable existence and direction of current flow on the pipes. Such drop measurements cannot, however, be used for calculating the amount of current on the pipes. To determine the actual current flowing it is necessary to measure the drop between two points on a continuous length of pipe by means of a millivoltmeter. This drop expressed in volts divided by the assumed or measured resistance in ohms of the included length of pipe gives the current expressed in amperes. A convenient table giving the current in amperes for one millivolt drop in one foot of pipe is appended to this paper for standard wrought-iron and standard cast-iron pipes. To find the current flowing in a pipe corresponding to a given drop in millivolts for a measured length, multiply the amperes given in the table for one millivolt drop for one foot by the number of millivolts drop measured, and divide by the included length of pipe in feet. To measure this drop, it is necessary to expose the pipe and to make good electrical contact between the millivoltmeter leads and the pipe. A satisfactory method is to use a pointed piece of steel, about the size of an ordinary lead pencil, fastened in a wooden handle, with a flexible connecting wire soldered to it inside of the handle. The pointed steel is then pressed against a bright spot or into a filed notch on the pipe. A still better contact is obtained by soldering the connecting wire directly to the pipe or to a brass plug screwed into the pipe, which is particularly advantageous when readings are to be taken over a considerable time. When such contact wires have been soldered to a continuous length of pipe, it is usual to use rubber covered wires and bring them to the surface of the street, leaving the ends in drip or service boxes which then form permanent test stations for electrical measurements. This is exceedingly convenient because it is then possible to make current measurements on the pipe without again making an excavation. Such permanent contact wires for electrical tests are illustrated in Fig. 4.

When drop measurements between services and current measurements on pipes have been generally made on a piping system, the results are conveniently plotted on a skeleton map of the city in which the pipe lines are shown and the current flowing on these pipes are indicated by arrows. A typical current survey map of a portion of a city is shown in Fig. 5. It is seen that here the currents on the pipes flow in a general direction toward the railway sub-station.

Since current destroys the pipe only where it leaves for soil, it is important to know where the current leaves the pipe. Current measurements on pipes are, therefore, frequently made at two or more stations simultaneously in order to determine the change of current on the pipe between the stations. In Fig. 6 simultaneous current measurements made at two stations on a pipe are shown plotted where there is no change of current between the stations. In Fig. 7 simultaneous current measurements at two stations on a pipe where there is a considerable loss of current between the stations are likewise shown.

In order to determine the characteristic variations of a potential difference between pipe and rails, or of current flow on a pipe, twenty-four hour records of such potential difference or of current flow may be obtained by means of a special Bristol smoked chart recording instrument. This recorder has for its measuring system a sensitive Weston millivoltmeter, and may be provided with a number of ranges. It is convenient to have the instrument provided with its zero in the center of the scale, and with ranges of 5, 50 and 500 millivolts, and of 5 and 50 volts. Shunts of any desired ampere range can also be used in connection with the recording millivoltmeter, and the instrument used as a recording ammeter of a corresponding range. Convenient shunts for this are ordinary switchboard shunts adjusted for 50 millivolt drop, with rated capacities of 5, 50 and 500 amperes. Such potential and current records are conveniently plotted from these charts in rectangular co-ordinates. Sample twenty-four hour records of current on a pipe plotted in rectangular co-ordinates for one week are shown in Fig. 8.

It will be seen from Fig. 8 that the current records for week days are practically alike, and show morning and early evening peaks. The record for Sunday is, however, very different and shows a very large peak throughout the whole afternoon. This is accounted for by the fact that the neighboring trolleys were carrying large crowds of excursionists on Sunday outings. By means of such twenty-four hour records, it is often possible to positively identify the source of current flowing on a pipe as railway current from its similarity with the railway load curves. Twenty-four hour records of current flowing on pipes may also be obtained at two or more stations simultaneously, and the change of current between the stations for the twenty-four hours determined.

It is possible to trace the path of current flow through ground by measuring potential differences between points in the ground. Where small potential differences are measured between two points in ground and iron rods are used as electrodes, entirely incorrect results may be obtained because of possible differences in polarization voltages at the surface of the electrodes. To overcome this difficulty, a "non-polarizable electrode" was devised by Prof. Haber. This consists of a glass tube with a porous cup cemented to one end and containing a saturated solution of zinc sulphate, and of a zinc rod dipping

* A lecture delivered before the American Water Works Association at Louisville, Ky., June 6th, 1912.

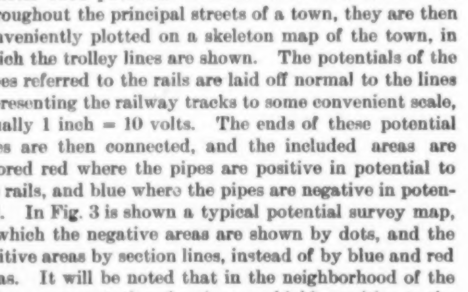


Fig. 3.—Typical Potential Survey Plotted on Skeleton Map of City, Showing Electric Railway Tracks and Potentials of Underground Pipes Referred to Trolley Rails.

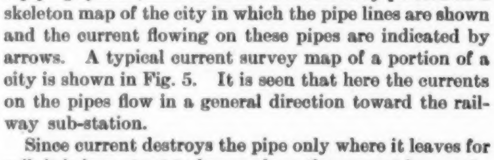


Fig. 4.—Permanent Electrical Test Wires Attached to Main, and Brought to Surface of Street Through Service Box.

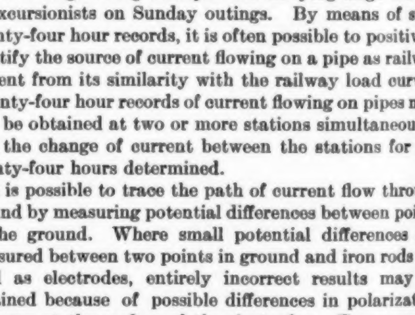


Fig. 5.—Typical Current Survey Plotted on Skeleton Map of Section of City, Showing Underground Mains and Stray Currents Flowing on Main.

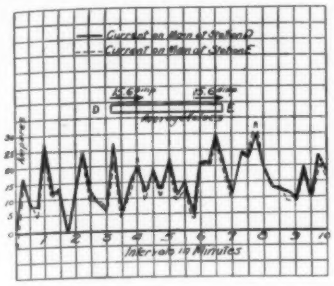


Fig. 6.—Simultaneous Current Measurements at Two Stations on Pipe Where There is no Change in Current Between Stations.

into the solution. A wire is brought out from this zinc rod through a cork in the top of the tube. To make contact to ground with this electrode the porous cup is pressed against the part of the ground at which the potential is to be measured, thus establishing contact between the ground and the zinc sulphate solution. This establishment of electrolytic contact between ground and the zinc sulphate solution eliminates polarization voltages. The polarization voltage between the zinc rod and the zinc sulphate solution, which is a definite known voltage, must be allowed for when using this electrode. It is also essential that when this electrode is used, the potential measurements be made by means of zero methods, and not with indicating voltmeters, because of the very high contact resistance produced with this electrode.

It is often also desirable to measure directly the flow of current through ground, as between a pipe and rails, or between two pipes. This can be done by means of an earth ammeter, which was also devised by Prof. Haber. This consists of a wooden frame with two copper plates insulated from each other by a plate of mica or glass. Insulated copper wires are brought out from the two copper plates, and these wires are connected to an ammeter. To use the frame, the two copper plates are first coated with a paste made of copper sulphate and a 20 per cent sulphuric acid solution. A wetted piece of parchment paper is then laid over the paste, and the remainder of the frame filled with soil from the excavation where the current flow through ground is to be measured. The frame is then buried in ground normal to the direction of the current flow to be measured, and the ammeter will indicate the current flow which is intercepted by the buried frame. The object of the copper sulphate paste on each plate is to equalize polarization potentials at the surface of the copper plates. This earth ammeter is also well suited for measuring current flow between pipe and ground. For this purpose the frame is buried in the ground one or two inches from and parallel to the pipe. Measurement of current flow from a pipe thus made can be used to form an estimate of the probable amount of electrolytic damage to the pipe, and in cases where corrosion has taken place, this kind of test will often serve as evidence that the corrosion has been caused at least in part by stray currents leaving the pipe. By using a recording instrument in connection with the earth ammeter, the characteristic variations of the current leaving a pipe can also be determined and in this way the identity of the current can often be established.

From a study of the results of the survey it can be determined where current is leaving the piping. At a number of such points excavations should then be made and the exposed pipe examined with a test hammer for electrolytic corrosion. Where such corrosion and pitting are found at points where current is found leaving the main, it may be taken as evidence that the destruction was caused by electrolysis, because it has been conclusively proven that current cannot leave iron for surrounding soil without producing corresponding destruction of the iron.

Regarding the use and value of an electrolysis survey, it must be remembered that the object of the survey is to indicate the existence or non-existence of stray electric currents upon a piping system, and to determine where such currents flow on to the pipes and from the pipes. I have had occasion to examine a large number of electrolysis surveys and have found that many of these consist exclusively of voltmeter readings. Such readings by themselves do not afford a measure of electrolytic

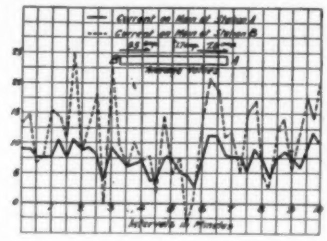


Fig. 7.—Simultaneous Current Measurements at Two Stations on Pipe Where There is Change in Current Between Stations.

danger; they merely indicate where the greatest danger is likely to exist. Measurements of current flow on pipes are essential in an electrolysis survey because all current which flows on a pipe must leave it, and the amount of damage produced is proportional to the total current which leaves the pipe. I have seen some reports on the other hand, where it is stated that the current on a given pipe is zero, but where the instruments and methods employed were not sufficiently sensitive to detect current as large as two or three amperes, and where, therefore, the conclusion of zero current is not warranted. From a complete and properly analyzed electrolysis survey, a great deal of good can generally be accomplished. It will not always be possible to remove all stray currents from the pipes, but measures will be indicated by which the conditions can be greatly improved, and points of greatest danger will be located. If then trouble does occur at a later time at these points, the electrolysis survey may be most valuable in affording proof of the destruction of the property from railway currents and may be the means of compelling the railroad company not only to pay for the damage but also to make improvements in its return system so as to avoid the recurrence of such damage. I know of a number of electric railroad companies who are regularly paying for damage caused by electrolysis to piping systems. The knowledge that a pipe-owning company is making electrolysis tests and is keeping watch on the situation, also has a strong moral effect on the electric railroads.

DAMAGE AND DANGER PRODUCED BY STRAY ELECTRIC CURRENTS ON UNDERGROUND PIPING.

It has already been pointed out that damage from electrolysis to underground piping usually results in the neighborhood of the power station from current leaving the pipe to flow to the rails and to other return conductors, and that service pipes in the same locality are most frequently damaged where they cross under and are positive to trolley rails. The destruction of underground piping by electrolysis is however by no means confined to positive districts in the neighborhood of the railway power station, but will occur at any point in the pipe where current leaves the pipe to flow to the surrounding soil. In Fig. 10 is shown a water pipe and trolley line near a salt water bay, about eight miles distant from the railway power station supplying this trolley road. The trolley rails at this point are about 25 volts positive to the water pipe, that is, the water piping is in a highly negative district. The railway power station is located on the shore of a salt water bay, and its negative bus-bar is grounded through low resistance ground connections, so that large currents leak from the trolley rails at points shown in Fig. 10, and flow through the ground and the salt water of the bay to return to the negative bus-bar at the railway power station. These stray currents in their path encounter the water main and flow part of the way on the water main. The values of current indicated on the main are average values obtained from 24-hour records. It is seen that in one section large currents leave this water main to flow to the surrounding soil and from there to the salt water. An examination of the main at this point also indicated that it had been badly corroded by electrolysis. This, therefore, affords an excellent example of destruction by electrolysis of a water main in a highly negative district.

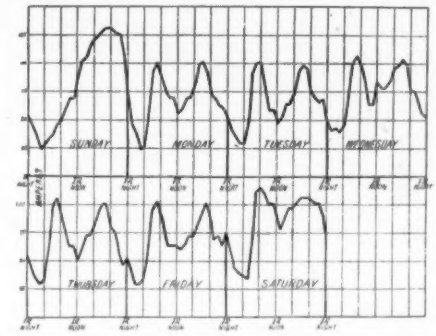


Fig. 8.—Stray Currents on Water Main Averaged from Bristol Twenty-four Hour Records and Plotted for One Week.

In Fig. 9 is also shown a water main and service pipe crossing under trolley rails and under telephone ducts. At this point the pipe is also negative to the trolley rails, but positive to the lead sheaths of the telephone cables, the potential condition with reference to the cables being caused by the fact that the telephone cable sheaths are bonded to the railway return conductor at the power station. As shown in the diagram, current flows from the rails to the water pipe, and leaves the water service pipe where it crosses under the telephone ducts to flow to the cable sheaths, resulting in the destruction of the service pipe. An examination showed pits extending entirely through the service pipe directly under the telephone ducts and facing the ducts. This, therefore, affords another illustration of destruction of a service pipe in a negative district.

Besides danger from electrolytic destruction of the pipes, stray currents where they flow on underground piping systems frequently enter buildings through service connections and produce a serious fire hazard. For example, current may flow into a building through a water service pipe, then flow from the house water piping to the house gas piping, and then out from the building through the gas service pipe. An example of this kind frequently met in practice is illustrated in Fig. 11. Such contacts between service pipes or between a service pipe and the lead sheathing of a telephone or a power cable frequently occur through metal ceilings, or where the pipes rest against each other. Since dangerous heating may be produced where the current flows through such contacts or where vibration may momentarily separate the contacts and produce an arc, nearby inflammable material is in danger of being set on fire. The author has in fact found many cases where currents up to 30 amperes were flowing into and out of buildings through service pipes or lead cable sheaths. Evidences of arcing having occurred between such contacts in buildings have also been found. There is no doubt that many fires have started in this way, but it is always difficult to prove the cause of a fire because of the destruction resulting from the fire.

To be continued.

Electric Charge of Rain

A. Baldit has confirmed the observations of Simpson and Kähler that rainfall usually brings down with it positive electricity, occasions when negative charges are observed being comparatively rare. Further observations at Puy-en-Velay give the following results: Ratio of duration of positively-charged rain to negatively-charged is 2.86; ratio of quantity of rain positively charged to that negatively charged is 2.38; ratio of total positive charge to total negative charge is 1.36. The rains were subdivided into three classes: (1) non-stormy, (2) stormy, (3) line-squall, and the above ratios were computed for each class. Class (1) gave the highest ratios, 5.3, 4.3, and 2.3, respectively; and Class (3) the lowest, 1.1, 1.2, 1.1, showing that quiet rain is associated with positive electricity, and that the rain of line-squalls is frequently charged negatively. Further, it appears that the average negative charge brought down per unit volume of rain is considerably greater than the average positive charge. After lightning, great fluctuations occur in the charge brought down, the sign of the charge being frequently reversed.

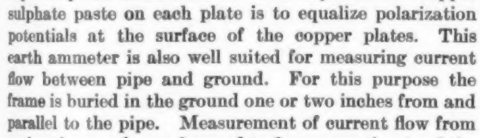


Fig. 9.—Example of Service Pipe Negative to Trolley Rails and Destroyed by Electrolysis, Owing to Currents Flowing from Rails to Pipe and from Pipe to Telephone Cable Sheaths.

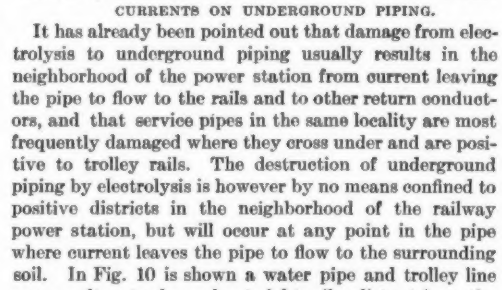


Fig. 10.—Diagram Showing Stray Currents Leaving Water Main in Negative District.

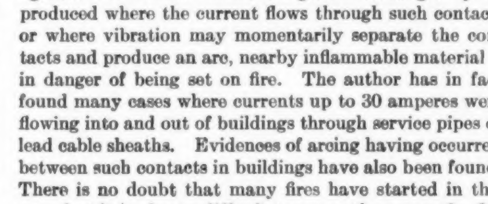


Fig. 11.—Diagram Showing Stray Currents Entering and Leaving Building Through Service Pipes and Causing Fire Hazard and Also Destroying Gas Service Pipe by Electrolysis.

The Technical Problems of Coal Preparation*

Waste by Attrition Must be Kept Down to a Minimum

By W. S. Ayres, C.E.

The problems involved in the preparation of coal begin in the mine itself and before the coal is even cut, and end with the loading of the prepared product into transportation cars ready for market. For the solution of these problems the engineer must bring to his aid geology, petrology, mineralogy, chemistry, hydrostatics, pneumatics and mechanics. These sciences have, after much study and a long-continued experimentation with every variety of coal, divulged the limits within which their respective groups of natural laws can be used for the accomplishment of the end sought. Any practice outside of these definite limits is sure to lead to disaster.

Having these guiding principles at hand, the continuity, uniformity, and structural nature of the beds of coal are determined, from which the system of mining and cutting is formulated; the physical peculiarities of both the coal and the refuse are carefully studied and the methods of handling and preparation are definitely selected; the degree of purity possible in the preparation, the possible percentage of recovery, the economy of the process adopted, and the market value of the prepared product, are also determined.

In the mine it is of great importance to first determine the recoverable tonnage in the coal beds, and from these data to determine the daily capacity of the proposed preparation plant.

The method of mining the several seams should be governed chiefly by the manner in which the refuse is associated with the coal. The breaking of the slates and rock into small pieces, in the cutting or blasting of the coal, must be avoided as much as possible for the reason that the larger the pieces of refuse and the smaller the quantity of it that is finely broken the simpler and less expensive the preparation of the coal for market will be. Wherever a shaly roof clod is free to fall as soon as the coal is removed, every economic means should be resorted to to prevent it from mixing with the coal.

But it is also of very great importance in the preparation problem to determine what alterations, if any, have taken place in the coal beds from folds in the strata. These folds, wherever found, have altered to a greater or less degree the fracture of the coal. In many cases they have crushed the coal almost to a powder, particularly where they occur in the anthracite and semi-anthracite fields. In others, the folding has caused a shale-like fracture of both the coal and slate. Upon the presence of the flat fractured material, in considerable quantity, chiefly depends the selection of the preparation scheme. There are some other conditions, however, which may materially modify that selection, namely, the manner in which the refuse is associated or combined with the coal. It may be associated in a very simple way, consisting of bands of slate or rock a half inch or more in thickness, which separate from the coal, in the process of mining, by distinct dividing planes, or it may be combined with the coal without any partings, and can only be separated from it by hand tools or by repeated crushing in the preparation plant.

As to the transportation of the material from the working places in the mine to the preparation plant, it should be done in closed-end cars. The method of handling closed-end cars at the dump is simple enough after full provision has been made for the system. The saving of coal filtered through the doors along the gangways and haulage tracks, the saving in labor necessary to periodically clean up these tracks, the avoidance of accidents from the doors springing open, the saving in repairs to the mine-cars because of the absence of the car doors and the safer condition against dust explosions, would pay a dividend over any advantages that may exist in favor of the open-end or door-car.

The preparation of coal, whether anthracite, bituminous or lignite, or any of the grades between or beyond them, must make use of the same natural laws, namely, those governing the difference in specific gravity and those governing the difference in the angle of repose. One of these groups may be perfectly efficient in preparing one coal having certain physical characteristics, while for another coal the other group would do perfect work, and for the almost infinite mergings of the two typical classes of coal a series of combinations and modifications of the two principal methods would have to be employed.

In the anthracite fields of Pennsylvania, the preparation of coal has been carried to the highest degree of efficiency and economy known to the world, yet the problem in all its details is not yet satisfactorily solved.

In the earliest days of anthracite mining in Pennsylvania only pure lumps of coal were shipped, and to obtain these only the purest beds of the series or the purest benches of a single bed were mined. The fine coal which would pass through a mesh of about two inches was sent out to the waste-bank. No attempt was made to mine the entire bed, or to systematically prepare the coal either by sizing or by removing the impurities.

The governing factors in the preparation of any coal are, to send the coal to the consumer in a condition suited to his requirements, and at a cost that leaves a margin of profit to the operator. The consumer's requirements are presumably based on the economic results that he desires to obtain, whether they pertain to steam generation, gas production, or metallurgical processes. Therefore, to meet his requirements, which set the standards for sizes and purity, the producer must search out ways and means, within economic limits, to prepare his coal. The economic end of this problem is not an easy one, and consequently because of the extended and intricate nature of the preparation requirements for some complicated deposits of coal, added to a difficult mining proposition, there is but little profit left to the operator; therefore, it is easy to understand why one operation will not pay a profit, while another with a different deposit pays handsomely. Each must prepare its coal according to the same standards for size and purity, no matter what it may cost, and receive for its prepared product the same market value.

In the specific gravity process of preparation, typified in the jig, many perplexing problems have arisen and many annoying results are always present, depending for their degree of seriousness upon the physical nature of the material being treated.

Any material in order to be treated in the most efficient manner by any process, must first be sized. The most efficient method of sizing coal as it comes from the mine, and that sizing must have a very limited range in variation, is by a series of shaking screens. The revolving screen is a thing of the past, because of its inefficiency, its destructiveness to the coal by chipping, and its reversal of the natural order of sizing. The mesh of these shaking screens is circular, and it is self-evident that this circular mesh will allow, but in a less degree than the old square mesh, all conceivable shapes of material to drop through it, provided that each individual piece has for the maximum dimension of its minimum cross section a measurement just a little less than the diameter of the mesh. The result is that the material as sized contains cubes, pieces that are triangular, round, oblong, rectangular, and square, having thicknesses that are very small compared with their other dimensions, and an infinite gradation of sectional areas between each of these typical shapes and that of the cube. The specific gravity of the slate and rock ranges from 1.90 to 2.50, while the specific gravity of the coal averages about 1.50. It is a very easy matter for any one to demonstrate by a few simple calculations, using the specific gravities of the coal and refuse just given and applying them to the various shapes of pieces given, that a cube of pure coal will tend to pass out of the jig with the refuse, while the thin flat pieces of slate of the lighter specific gravity are sure to float over with the coal. The reason for this is that the ratio of the area of surface of the cube of coal, exposed to the impulses of the water in the jig, to its weight, is greater than the ratio between the area of surface exposed of a thin light piece of slate and its weight. These very inefficiencies are experienced wherever this class of variformed material is treated by the jig. The inherent conditions make the failure of the jig a natural consequence, and confirm the conclusion from tests that no jig can be made to separate efficiently a material containing a variety of forms, particularly cubical pieces of coal and flat pieces of light slate. Much time and money have been spent in a fruitless endeavor to meet the condition by introducing some new and untried form of jig, with the same inefficient results. A thorough grasp of the technical features of this problem would at once show clearly the limits of the possibilities of coal preparation by this process alone.

The attrition in the jig caused by its rapid pulsations amounts to a serious waste of coal, ranging from 2 per cent for the very hardest coal to 21½ per cent for the softest anthracite, or at the present market value of prepared sizes to from 8 cents per ton to 89 cents per ton. The average loss sustained is estimated to be between three and five per cent. The total loss per year by chippings alone on coal treated by the jig and separating machines causing impact in the anthracite field of Pennsylvania is estimated to be more than three million dollars ($3,000,000).

Of the other mechanical devices for removing impurities from coal there are three that are extensively used, each employing the difference in the angle of repose between slate and coal as the basic principle of its operation.

The first is so constructed that a broad stream of material, about 5 feet wide and spread out in such manner that the pieces in their forward movement will not touch each other, is intermittently fed upon a short adjustable inclined floor, at the lower edge of which is a narrow section of slate or other gritty material. Immediately below the section of slate is a narrow opening of several inches and beyond this is a continuation of the inclined floor. The action is that the refuse passing over the slate section of the floor is retarded and drops through the narrow opening, while the coal because of its less angle of repose continues over the slate section with only slightly retarded velocity and jumps across the narrow opening and upon the continuation of the inclined floor below. The serious objection to this type of machine is the great loss due to the chipping of coal as it impinges against the upper edge of the continued floor below the opening. The loss is reported to be greater than that in the jig.

The second consists of a spiral floor descending and inclined inwardly toward its vertical axis. It depends for its operation upon the inward inclination of the floor toward the vertical axis tending to draw the slate in its retarded movement toward the axis, while the coal in its accelerated movement down the spiral incline is thrown from the floor by centrifugal force and is caught in a specially provided runway paralleling the spiral floor and spaced a little distance from it. This separating device is also very destructive to the coal as each and every piece as it leaves the spiral floor impinges against the outside of the runway. In quantity the loss is reported to be fully equal to that in the jig.

The third device consists of a moving floor inclined forwardly and transversely. The motion of the floor is upward on the transverse inclination. Both inclinations are adjustable. The material travels across the floor on its longitudinal inclination. The upwardly moving floor removes the impurities laterally from the forwardly moving stream. The coal slides upon the moving floor and across it without any impact. The loss sustained in this separator is less than one half of one per cent. This machine is the only one that does not create material loss by attrition or chipping.

The tendency in the practice of to-day is to use as extensively as possible the machines that do not create loss, therewith turning to the pocket ready for market from 60 to 80 per cent of the pure coal coming upon the machine, and without appreciable loss from chippings. This operation removes all of the cubical coal which gives unsatisfactory results in the jig. A second operation supplements it, retreating the tailings of the first, which removes the flat slate and heavy rock. This operation is again supplemented by a third, jigging, which removes the remaining slate in the balance of the coal. This three-stage process has the advantage of great elasticity and controllability.

The most important of all features in the entire process of anthracite preparation is to so handle the coal in transportation, screening, separation, conveying and loading as to retain the pieces of coal whether coming directly from the mine or from the crushing-rolls in their initial form without any loss in weight from abrasion or chipping, if at all possible to do so. The crushing-rolls must be of the type that will yield the very highest percentage of the prepared sizes, for in these sizes the values lie. These sizes are egg, through 3 1/4 and over 2 5/16-inch round mesh; stove, through 2 5/16 and over 1 5/8-inch mesh; and chestnut, through 1 5/8 and over 15/16-inch mesh.

The foregoing reference to the losses sustained in the process of jigging and in certain types of the frictional machines accentuates the importance of this feature of the process.

Great attention should be given to the avoidance of breakage in the transportation of the coal from one stage of the process of preparation to the next and finally

* Paper presented to the Eighth International Congress of Applied Chemistry.

its delivery into the deep pockets holding as much as 100 to 200 tons for each size. One of the most efficient means of doing this is by the spiral-chute first introduced in 1896 in a breaker near Hazleton, Pa., by the writer. Another efficient device is the "waterfall-chute" first introduced in 1910 in the Lehigh Valley Coal Company's breakers, by Paul Sterling, mechanical engineer for that company. It consists of a series of comparatively narrow floors in two vertical tiers, inclined toward each other and overlapping. Different dimensions are required for each size of coal. In its operation the coal flows from one floor upon the next floor below in the opposite tier, and so on, making the descent without material breakage. Either of these devices will deliver the coal to any vertical depth desired.

In like manner great savings can be effected with the exercise of due care in the design and construction of the loading devices. To illustrate the possible loss at this point in the process, it has been found by test that prepared sizes dropping 10 feet will depreciate 4 per cent in fine chippings.

The preparation of bituminous and lignite coals must in a general way follow the same plan as that developed in the preparation of anthracite. This is manifestly so because the general formation of the beds and association of the impurities is the same. But because of the friability and soft nature of these coals the process has been modified to suit this inherent peculiarity. A close examination of the surface of the sized pieces of bituminous coal shows that the interlaminated bands of slate, although they may be as thin as India paper, protrude beyond the bands of coal, the coal having been worn or frayed away in the action of loading, dumping and screening. It is also observed that the very purest of pieces of bituminous coal have a greater angle of repose than even the least pure pieces of anthracite, showing that the slates are more silicious. It is plain, therefore, that the jig, because of the friability of the coal, would not succeed within economic limits. On the other hand because of the projection of the silicious interlaminated bands of slate beyond the surface of the coal the frictional machines have only a very limited range of efficiency. Any type of machine that produces impact will create serious disintegration and loss. Crushing the coal to half-inch mesh, and under, and treating it in a washer has proved very unsatisfactory and wasteful of the finest particles of coal, which have an equal value with the coarser particles in making coke, or for steam purposes and gas producing. Many ingenious schemes have been brought out to accomplish the coveted end. One scheme has recently been brought forward whereby the coal is treated entirely in the dry state, without the use of any water, and which recovers, it is claimed, about 98 per cent of the values of the coal.

The market value of any coal depends primarily upon the number of heat units per pound. In the anthracite field the standards of purity are expressed in percentages of slate in the coal, this being a convenient and reasonably accurate way of expressing the purity of the coal. It is made possible to express it in this way because of the hardness of the coal and the sized condition of the prepared product. In the bituminous field, because of the presence of so much fine material in the product, the chemical analysis determining the heat units and percentage of ash, sulphur, etc., must form the basis from which the value of the coal is determined.

In designing a preparation plant the recognized scientific principles underlying all of the methods of preparation together with the individual peculiarities of the coal to be treated should unquestionably form the basis for formulating the scheme. If these principles are consistently adhered to a better preparation and more economic results will be obtained than can be obtained from trying to correct some inherent defects in the old methods, or to modify them beyond their fixed limits of efficiency.

A New Alloy with Acid-Resisting Properties*

By S. W. Parr

While marked advances have been made in the development of alloys with properties which render them resistant to the corroding influence of the atmosphere, not so much study has been given to the production of alloys which would resist the solvent action of strong chemicals. This latter function of resistance to chemical action has been given over almost wholly to the noble metals. However, there are certain specific requirements such as ordinarily call for the use of gold or platinum where the quantity of metal involved and the excessive cost of the same make its use almost prohibitive. These considerations have led to the studies herein described in which the effort has been made to develop an alloy especially resistant to nitric and sulphuric acids.

A preliminary study was first made of certain of the more common alloys with a view to determining their relative solubility in nitric acid. An arbitrary strength of acid was chosen which was obtained by diluting the ordinary strong acid of 1.42 specific gravity in the ratio of 1 of acid to 3 of water making approximately a 25 per cent or 4N solution of HNO_3. The alloys employed together with their order of solubility is shown in Table I.

TABLE I. RELATIVE SOLUBILITY OF METALS AND ALLOYS IN 25 PER CENT HNO_3.

Amount dissolved in 24 hours.

	Per Cent.
1. Pure iron 99.8 pure	100.0
2. Commercial Aluminium	51.4
3. Monel metal	19.2
4. Nichrome Ni 90, Cr 10	7.9
5. Copper Aluminium, Cu 90, Al 10	3.5
(79) (20) 1	
6. Nickel chrome aluminium	1.3
7. Ferro Silicon	0.1

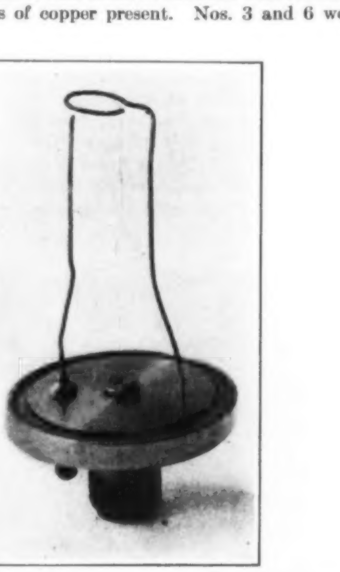
The tests in Table I were based on the per cent dissolved in 24 hours at room temperature. They are of value only as they show relative solubilities. Test pieces were used of approximately the same superficial area. The amounts dissolved expressed as percentages are sufficiently accurate for comparison. The range of solubilities varies widely being from 100 to 0.1 per cent.

The last two items on the list suggest the possibility of carrying the series further. Because of its physical characteristics of brittleness, lack of working qualities, etc., the last number, ferro silicon, was not selected as affording an encouraging basis for experimentation. The next to the last number, however, the nickel chrome compound with a small amount of aluminium was selected as a suitable type for further study. A series of six mixtures was arranged as in Table II wherein it was sought to determine the effect of the introduction of copper. Some such modifying element seemed necessary for the reason that the value of No. 6 in Table No. I was nullified to a large extent by reason of the difficulty experienced in casting that material free from flaws. The melting point of the mixture was extremely high, approximately 1,500 degrees, and it was thought that by the introduction of a metal of lower melting point a product would be obtained which would flow more freely and solidify without blow holes. The series arranged, therefore, was a nickel-copper-chrome combination with decreasing amounts of copper and increasing percentages of chrominum as shown in Table II.

TABLE NO. II.

Series No.	1	2	3	4	5	6
Ni	65	80	80	80	75	70
Cu	30	10	5	5	5	10
Cr	5	10	10	15	20	20
Soluble in 25% HNO_3–24 hours	easily soluble	1.25%	.02%	.05%	.013%	.023%

The interesting fact developed in this series was the degree of resistance that could be attained with considerable quantities of copper present. Nos. 3 and 6 were substantially of the same resistivity but No. 3 was more sluggish in pouring. Very little difference could be detected between Nos. 5 and 6, hence the latter was taken as a basis for further experiments. It was evident from the impossibility of securing perfect cast material from No. 6 that a study must be made of purging agents to clear the bath of oxides and dissolved gases. Aluminium could be used to advantage in this regard while at the same time the resistance to the acids was slightly increased. Tungsten was a slight further aid and manganese up to an amount equaling 1 per cent did not appreciably augment the solubility factor. Other deoxidizers and denitrifiers in various forms were used such as boron, silicon, titanium and vanadium. The effect of the last one, seemingly, to increase the solubility. The others in fractional percentages, were effective both in improving the resistivity and the texture as well. The average range of values employed was approximately as shown in Table III.



Calorimeter-bomb Cover Made of the New Alloy.

Not all of the difficulties of casting the material have been eliminated by any means. In proportion as the texture and soundness have been improved upon, the difficulties connected with casting the material have increased. The contraction of the metal at the moment of solidification is very pronounced and shrinkage cracks are very likely to occur. However, these difficulties are chiefly mechanical and can doubtless be finally overcome. The alloy draws into wire and spins radily and may have numerous interesting applications.

TABLE III. SHOWING COMPOSITION OF ACID RESISTANT ALLOY.

Ni	66.6
Cr	18.0
Cu	8.5
W	3.3
Al	2.0
Mn	1.0
Ti	0.2
B	0.2
Si	0.2
	100.0

TABLE IV. SHOWING LOSS IN MILLIGRAMMES PER 100 SQUARE CENTIMETERS PER HOUR. THE ACID IS 4—NORMAL IN EACH CASE.

No. of Melt.	HNO_3	H_2SO_4	HCl	1 Vol. HNO_3 2 Vol. H_2SO_4
23	0.03	....	....	1.95
..	0.03	0.79	1.95	1.98
..	0.50			...
..	0.06			...
25	0.19			...
40	0.4			0.09
..	0.3			0.10
..	...			1.00
54	0.3			0.8
60	0.2			4.8
..	0.4			5.2
64	2.0			0.3
..	1.85			0.2

The various melts differed slightly in composition, the attempt being made to determine the limits of certain ingredients especially manganese, copper and aluminium. The best results were obtained with compositions conforming most nearly to the values given in Table No. III. The solubility in sulphuric acid was found to be as a rule no greater than in nitric acid, hence, the solubility tests were made on mixtures of the two instead of upon the sulphuric acid alone. Very few tests on hydrochloric acid were made. As a rule the solubility of this type of alloy is considerably greater in hydrochloric acid than in nitric or sulphuric acids. The more detailed examination of the structure, solubilities, physical and electrolytic properties has been deferred until a practicable or workable alloy could be obtained. This has now been accomplished in a very satisfactory manner and further work as above indicated will be continued. As illustrating the practical value of the alloy a calorimeter bomb was constructed and has already served for heat determinations upon an extended series consisting of sugar, benzoic acid, ethyl-benzene and coals. The pressures employed have ranged from 25 to 50 atmospheres and charges of material up to 1½ grammes have been used. The results are all that could be desired. An illustration of the cap or cover to the bomb is given herewith. The interior surface which comes in contact with the corroding gases retains its polish and luster without any evidence of chemical action.

*Paper read before the Eighth International Congress of Applied Chemistry.

An Experimental Study of Vortex Motion in Liquids—I*

Lord Kelvins's Smoke-ring Model of the Atom

By Edwin F. Northrup, Ph. D., Palmer Physical Laboratory, Princeton University

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It is not improbable that the first observer of vortex motions was Sir Walter Raleigh; if popular tradition may be credited regarding his use of tobacco, and probably few smokers since his day have failed to observe the curiously persistent forms of white rings of tobacco smoke which they delight to make. But some two hundred and eighty years went by, after the romantic days of Raleigh and Sir Francis Drake, who made tobacco popular in England, before a scientific explanation of smoke rings was attempted.

About 1867 Prof. P. G. Tait translated into English a most important mathematical paper by the German physicist Von Helmholtz. In this paper Helmholtz submitted to a rigid mathematical analysis the motions and the properties of vortices in an assumed perfect fluid, that is a fluid without viscosity. Tait's translation, which appeared in the *Philosophical Magazine*, immediately attracted the attention of Lord Kelvin, who saw in the results of the analysis of Helmholtz a possible explanation of the ultimate constitution of matter.

Tait illustrated the several points of the Helmholtz argument by some cleverly devised experiments with smoke vortices. He provided a large cubical box with a round hole in one side and a flexible diaphragm on the opposite side. Ammonium chloride fumes were generated in the box to provide the smoke. When the flexible side of the box was struck sharp blows, symmetrical and swiftly moving rings issued from the hole opposite. These possessed many of the curious properties which Helmholtz had predicted for the vortices in a perfect fluid. They had integrity of form and moved swiftly forward always in a line normal to their plane, and carried with them the same material with which they issued from the box. They seemingly possessed elasticity of form such that striking slanting-wise an object or another ring, they were thrown into violent vibrations, as if they had been hollow anchor rings of rubber or similar material. If a swiftly moving ring was made to follow close behind a more slowly moving one, the forward ring was overtaken and this, as the other approached from behind, would accommodatingly expand and allow the approaching ring to pass through it. The ring now in advance would then be overtaken by the first ring and in turn would expand to allow this to overtake and pass through it, the speed of the approaching ring having been increased by an apparent attraction, as between the rings.

These experiments were witnessed by Lord Kelvin who was deeply interested, and the ideas suggested he rapidly developed into his famous vortex theory of matter, in which the ultimate particles of matter are postulated as consisting of indestructible vortices in the ether. Essential to this theory is the supposition that a vortex filament of circular or other form, knotted or interlinked with another filament, would, if once created in a perfect fluid, endure forever. It might vibrate, encounter obstacles, expand or contract, but it could not be cut or broken into parts. Motion, whirling, rotary motion, about an axis or line closed upon itself, was the essence of its entity. According to Kelvin, one portion of space contains matter, if the ether in that space possesses vortex motion, while another portion of space is without matter if the ether in that space is not possessed of vortex motion. The atoms are vortices and are eternal.

In the many scientific memoirs which Kelvin wrote during this period, this novel view of a kinetic constitution of matter was supported with consummate skill.

It seems strange, however, that though the laws of vortex motion were exhaustively examined by the ablest mathematicians of the time, few if any experiments were made to study vortex motions in air and fluids, beyond the first experiments with smoke rings above referred to.

Finally, with the discovery of radium the entire scientific world, including Kelvin himself, adopted the more fruitful ideas regarding constitution of matter, which have become crystallized in the modern "electron theory."

That few experiments were tried appears the more astonishing, when it is considered that we have at our disposal such high density fluids as water and oils with free surfaces and small viscosity, in which beautiful vortex motions may be easily produced in great variety and of curious forms.

The experiments which are about to be described would, if made earlier, have possibly had a greater interest as bearing upon Lord Kelvin's ingenious theory of the vortex atom.

However, consider the electron which modern theory substitutes for the vortex atom. Calling it an elemental unit negative charge of electricity is but giving a name to something whose ultimate nature is as obscure as the hard atom of Lucretius made somewhat more thinkable by the Kelvin hypothesis.

The first crude experiments were of a kind such as to be reproducible with slight effort and little or no expense. In the center of the cover of a baking-powder tin a round hole, about 1 centimeter in diameter is made. This is filled with water colored with red or black ink and covered.

Care must be used to fill the tin completely so that no air remains. A porcelain bath-tub makes a most convenient water tank. This is filled nearly full and the tin, with its colored water, is submerged at one end of the tub. The tin is held horizontally in the left hand while a sharp blow is struck by means of a hammer in the right. A perfectly symmetrical vortex ring, somewhat greater in diameter than the hole in the tin, will be expelled and travel to the far end of the tub, reaching it in about a second. This production of visible rings may be repeated until water in tub becomes clouded with ink.

Two interesting properties of these rings may be tested at once. If the tin is held so that the ring grazes the side of the tub, it is, on touching the side, broken up and scattered, but if it be pointed so that the ring goes, not at too great an angle, toward the surface of the water, it is, on reaching or nearly reaching the surface of the water, reflected down from the surface. The angle of reflection is equal to the angle of incidence, and the ring preserves both its form and velocity. The plane of the ring always maintains itself perpendicular to its direction of motion, hence when reflection occurs the ring tilts its plane through an angle.

The experiments first made in this way seemed to promise a line of interesting investigation, if properly constructed apparatus was made and methods devised for the production of the rings under conditions that could be completely controlled and modified in various ways.

It was decided to construct a suitable outfit for making a series of qualitative observations of the properties of the rings and then, if it should prove possible, to take instantaneous photographs of them. Both plans were executed successfully and the outfit and methods employed will now be described in sufficient detail so that any one, who wishes to reproduce the apparatus and experiments and take photographs, may do so.

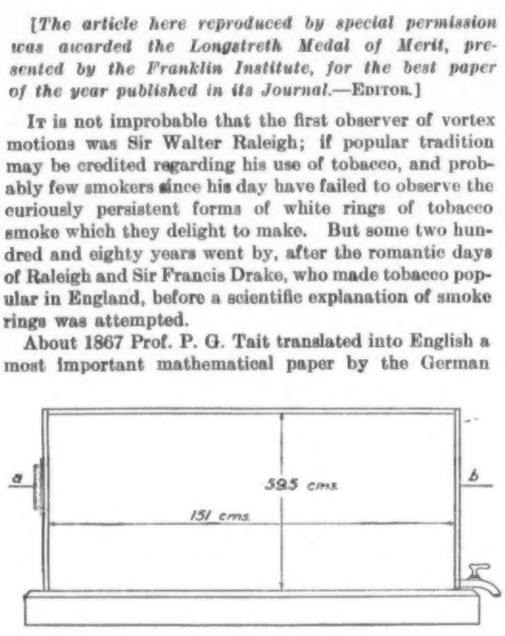


Fig. 1.—Diagram of Tank.

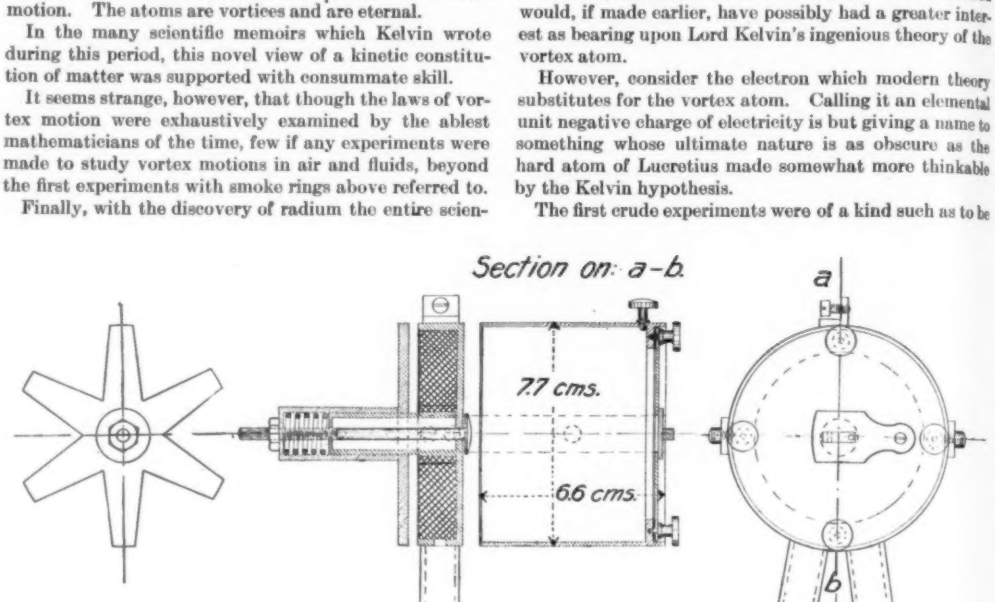
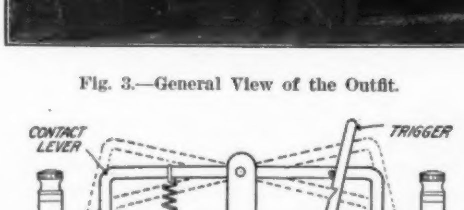


Fig. 2.—Working Drawing of Gun.

Fig. 3.—General View of the Outfit.



SHORT MAKE SWITCH

Fig. 4.—Gun Switch.

DESCRIPTION OF APPARATUS FOR PRODUCING LIQUID VORTICES.

It was recognized at once that a tank was required which would permit the rings to be observed from the side, the top, and the end. Furthermore, for continuous experimenting, the rings must be colored with a material which, when the rings break up, would entirely disappear and leave the water of the tank clear, for otherwise the tank would require repeated refilling.

Fig. 1 shows clearly the construction and dimensions of the tank used. The bottom and ends were of wood and the sides of clear plate glass 7 millimeters thick. Its inside dimensions were—length 151 centimeters, height 60 centimeters, and width between inside surfaces of the plate glass 12 centimeters. In one end was mounted a lens 10 centimeters in diameter, through which one could see with a clear focus almost to the far end of the tank when it was filled with water. In the end opposite to the lens, close to the bottom, there was a spigot for emptying the tank. The pressure of the liquid against the glass sides made them bulge out dangerously and removable brass straps were required to hold them together at the top.

The method of shooting the rings and the construction of the "gun" received much consideration, and after two years' experience with the first form constructed, no single detail seems to need change. An electro-magnet was used to produce the impacts upon the flexible metal diaphragm of the gun. The choice of an electro-magnet proved, later on, to be a wise one when the rings were being photographed, as the timing and force of the blow could be precisely regulated.

The gun was supported on brass rods in such a manner that it could be aimed in any desired direction by adjustments made above the water. The hole in the front end of the gun from which the rings issue could be closed or opened by means of a hinged metal piece which also was operated by a brass rod above the water. The gun proper consisted of a short cylindrical brass tube 7.7 centimeters in diameter and 6.6 centimeters long. On the front end of this tube was a removable disk of brass held in place against a shoulder with thumb screws. Disks were provided with holes of various shapes and sizes, and some with more than one hole. The flexible diaphragm in the back end of the tube was of phosphor bronze, well hammered to be springy.

The electro-magnet, for producing the impact upon this diagram was in the form of a split hollow anchor ring and of the same diameter as the tube. The armature was on the side opposite the tube and consisted of a disk of soft iron with six radiating fingers. The winding lay in the hollow of the anchor ring and was imbedded in wax. Access of water to the winding was further prevented by covering the open end with thin sheet brass. A rod was fixed to the center of the armature normal to its face and, passing through the center of the magnet, struck the diaphragm a sharp blow on the magnet being energized. The length of stroke was about 0.6 centimeter. The armature was returned to its original position by means of a spiral spring, after de-energizing the magnet. The winding was of No. 28 double silk covered copper wire and had a resistance of 17.5 ohms.

An important feature in the construction was a small thumb screw at the extreme front end of the tube and located on its upper side. After the tube had been filled and put under the water in the tank this screw was removed, and the last bubble of air made its escape. The complete removal of air was found to be essential to the formation of the best rings.

As the success of the experiments was largely dependent upon the construction of the gun, a complete working drawing of it is shown in Fig. 2.

As in some of the experiments it was required to note the effect of the collision and close passage of rings approaching each other from the same and from opposite directions, two guns were constructed. When their magnets were joined in series, rings could be ejected from the two guns at the same instant.

The entire apparatus including that employed for photographing the rings, is shown in Fig. 3 reproduced from a photograph.

The gun was operated from a source of direct current of 110 volts. As the circuit through the gun magnet could be closed only for an instant, a switch was devised so that by pulling a trigger the circuit could be made and quickly broken again. As this switch may be of use in other connections where a circuit carries a large current for a brief time, and as it is simple in construction it is shown in Fig. 4.

The rod of metal, bent down at each end and supported at its middle point on a fulcrum, has one end in a cup of mercury while in its initial position, and the other end in another cup of mercury when in its final position, to which it is drawn by a spring when a catch is released. Only when the rod is horizontal is each end in a mercury cup, thus closing the circuit from mercury cup to mercury cup.

This switch, together with a rheostat, was used in circuit with the gun and 110 volts. As the gun is under water a current of 10 or more amperes could be passed through the winding for a brief time without overheating. The plunger could, therefore, be made to give a very hard blow upon the flexible diaphragm and eject a ring at high velocity, and possessing considerable energy.

The problem of making deeply colored rings, which could be easily observed or photographed, but which on breaking up would leave the water perfectly clear, was successfully solved for rings of a deep red color and of a milk white color. For the red rings phenol phthalein was used. This substance is, as purchased, a white powder. To prepare it for use, a teaspoonful is dissolved in ethyl alcohol, just enough being used to dissolve it. This solution is then diluted with about two liters of pure water. It is then colorless or slightly milky in appearance. About a tablespoonful of strong ammonia is then added which turns the solution to a deep, rich red color. This is put in the gun. To the water of the tank, while it is being filled, to get good mixing, is added about an ounce of strong hydrochloric acid. The gun is placed in position in the tank and the last bubble of air is allowed to escape. The connections of the electric circuits are then made, when the apparatus is ready for shooting rings.

A ring when shot goes the length of the tank and preserves its form and color until it strikes the glass or end of the tank. When the ring breaks up the acidity of the water entirely destroys the red coloring matter of the ring, leaving the water of the tank perfectly clear, even after a hundred or more rings have been ejected. It was customary to refill the gun, however, after shooting about twenty-five rings, as they gradually grow paler.

For making milk white rings an emulsion of chloride of silver was used which also becomes colorless in a weak solution of ammonia. To make such an emulsion, which will not settle even after standing over night, a tablespoonful of clear gelatine should be boiled in a liter of water until completely dissolved; then mix with this about 15 grammes of silver nitrate crystals, which have been previously dissolved in water. Then add a weak solution of hydrocholoric acid, stirring well, until the nitrate is all precipitated as chloride. Care should be observed not to use an excess of acid. The result is a smooth, milk-white solution which will not settle, and will turn quite colorless in very weak ammonia water. This solution can be half diluted with water. The tank should be filled with weak ammonia water and the gun with the solution. Beautiful milk white rings can then be made in the same manner and with the same ease as red rings, and a large number may be shot without any clouding of the tank water.

(To be continued.)

Testing Lubricants*

A Machine for Studying Them Under Actual Working Conditions

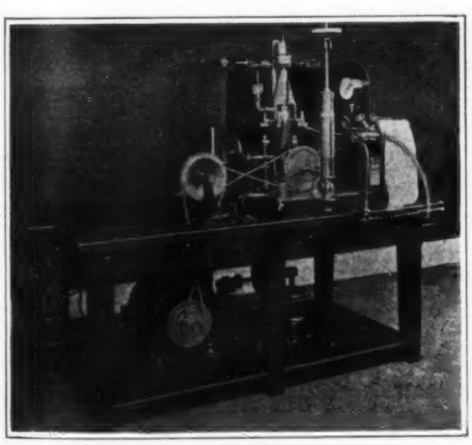
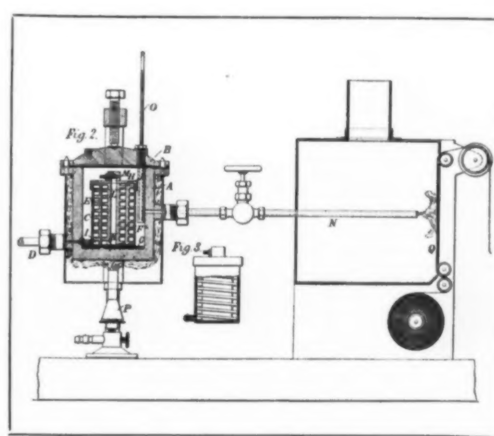


Fig. 1.—General View of the Machine.



Figs. 2 and 3.—Sectional View and Detail.

Every engineer knows that the reduction of friction to a minimum is one of the most important factors in the economical running of all kinds of machinery, yet the matter does not by any means receive the careful attention that it deserves. By this we mean that sufficient care is not always exercised in the selection of the best form of lubricant for different purposes, although a very great deal lies in this proper selection. To this it may be said that it is not always an easy matter to decide what is the most suitable lubricant to use, and there is no doubt a good deal of truth in this statement. But it has not now the same force that it had some years ago, in that there are at the present time available very accurate methods by which the properties of all kinds of lubricants can be ascertained. These methods are well worth attention, for it is only by them that the full advantage arising from modern improvements in the machinery equipment of any installation can be derived. In order to minimize the cost of power production and, at the same time, lessen the wear and tear of frictional parts of machinery, it is necessary to make use of the most suitable lubricating material, and in order to do this the user must know with certainty the economical value of a lubricant before actually putting it into use.

The data available hitherto have been obtained chiefly from chemical and physical analyses, but these alone are not sufficient and are frequently misleading. It is not enough to know, for instance, the percentage of acidity and pitchy ingredients in an oil, its specific gravity, flash-point and viscosity, etc., though these particulars are of value in their way; they do not, however, afford a reliable basis on which to judge of the suitability of the oil or grease for any given purpose. Of far greater importance are practical tests under actual working conditions, but such tests involve considerable risk and great and unnecessary expenditure of time and trouble.

Certainly, many plants are not using the materials best adapted to their requirements, and quite different qualities would, in many cases, be substituted if those in charge of the plants were fully informed as to the value of the lubricants relatively to the machinery on which they are used, and if there were available a ready means of determining the minimum of friction which should exist in the bearings when using the most suitable quality of lubricant. From this it follows that there may easily be a large and, at the same time, indeterminate waste of power and an undue degree of wear and tear of the frictional surfaces. Unfortunately there are, in most cases, no visible or audible signs to indicate that the oil or grease in use is not of the right quality to give the highest percentage of efficiency possible. It is here that the resources of the engineer frequently fail, for even if the oil be suspected as the cause of trouble, it is generally too lengthy and too risky a business to undertake the experiments necessary in order to set the matter beyond doubt and select another and more suitable lubricant. Thus the use of the oil, the efficiency of which is doubtful, continues, because of the lack of means for proper testing, and the plant continues to run under disadvantageous conditions. In some cases, also, the use of an inferior or unsuitable oil may be continued, because it is of a well-known brand and high priced, although its economical value may be less or, at any rate, no more than that of a considerably cheaper lubricant.

Recognizing the importance of being able to determine the practical value of a lubricant without being under the necessity of undertaking long and hazardous experiments in actual use, attempts have for many years been made to construct oil-testing machines, which have hitherto been mainly on the principle of a horizontal or vertical spindle with a surrounding bearing. These machines have all had one common disadvantage, however, that the concave and curved shapes of the bearing and spindle do not respectively admit of a sufficiently exact adjustment to each other. Under the first tests damage may occur to the frictional surfaces, which surfaces cannot be renewed

* Reproduced from *Engineering*.

exactly as they were before, and it is then impossible to establish with these machines a constant standard of the lubricating value of the oils under test. Moreover, these machines cannot satisfactorily test cylinder oils, and yet the determination of the lubricating value of such oils before actual use, whether for wet or dry steam, is very important; and particularly so in connection with internal-combustion engines.

In order to overcome these objections a machine has been invented which is now being placed on the market, which we illustrate. It has been constructed to meet the needs of the most widely varying plants, and to produce the conditions obtained in actual practice. It determines, and automatically records, the properties which govern the values of different lubricants when in actual use, and it is claimed that it is the first machine really available for the purpose, and that it has made clear many hitherto obscure points about lubricating media. The speed of the machine can be varied to produce the equivalent of from 50 to 3,000 revolutions per minute, that is, a speed of the frictional surfaces of about 5 inches to 25 feet per second. The pressure can be varied from 1 pound to 750 pounds per square inch, and the temperature can be raised from that of the frictional surfaces when at rest to about 450 deg. Cent. This is more than equivalent to the heat of dry steam produced under the highest pressures which occur in practise.

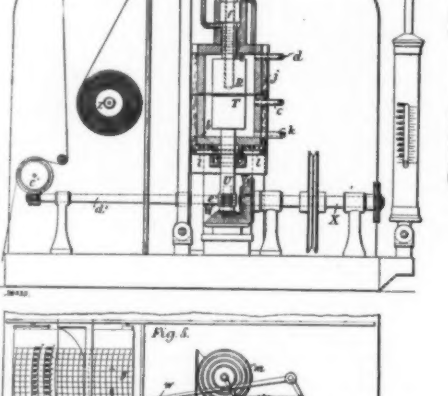
A special feature of the apparatus is that, by using it with a high-pressure steam-boiler or superheater, cylinder oil can be tested under actual working conditions. By exposing the oil to the influence of superheated or saturated steam for any period, it determines to what extent, if any, disintegration of the oils and formation of sediment takes place. After testing, the cylinder oil is, by means of steam or hot air, blown on to a slip of paper, on which is clearly seen the condition of the oil, and the changes it has undergone through the treatment to which it has been subjected. After this the oil is again tested in the machine itself, in order to determine what change has taken place in its lubricating value, through the influence of heat. On the same slip of paper the machine indicates automatically the degree of friction and the temperature of the frictional surfaces, and ascertains the absolute, as well as the relative, values of the lubricants. In this way a standard is established which enables the values of the frictional curves to be exactly expressed in figures. The temperature of the frictional surfaces is sometimes obtained by means of a thermometer and sometimes by a thermograph, which latter automatically registers the degree of heat on the same slip of paper on which is shown the degree of friction. The number of revolutions is indicated on a tachometer.

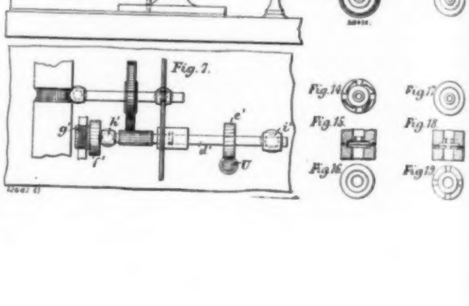
A general view of the apparatus in perspective is shown in Fig. 1, while the details may be seen in Figs. 2 to 19. The attachment for testing cylinder oils under dry heat and wet and dry steam is shown in Fig. 2. This part consists of a vessel A with a cover B, the vessel A containing another vessel C, which is in communication at the bottom with the pipe D, as shown, through which steam is admitted when the oil has to be tested in this way. Inside the vessel C are two cylindrical parts E and F, which are formed with spiral ribs on the outside, E being made to fit closely within the vessel C, and F within E. The vessel C stands upon an asbestos pad G, and has on it a cover H, which is screwed on. The vessel C is shown in part section with its cover in Fig. 3. The oil under test is fed into the steam, and enters with it at D, and flows into the outer spiral chamber at I, passes up the spiral and through the opening J into the spiral F, which it descends, going out at the bottom by the opening K to the central bore-hole L, whence it escapes into the chamber A through the opening M, and out of the chamber A into the pipe N. According to the nature of the mixture of steam and oil, any constituent from the latter tending to deposit settles on the surface of the spirals, and the amount and nature of such deposit may be ascertained by removing the covers B and H, and withdrawing the spirals, while, at the same time, the length over which such deposits extend may be readily seen, and, if desired, the deposits may be removed and subjected to further tests. The temperature of the steam is indicated by the thermometer O, and any desired temperature may be kept up by means of the burner P. After passing through the vessel A, the steam and oil can be blown through the tube N on to a slip of paper Q, on which is shown the condition of the oil after treatment.

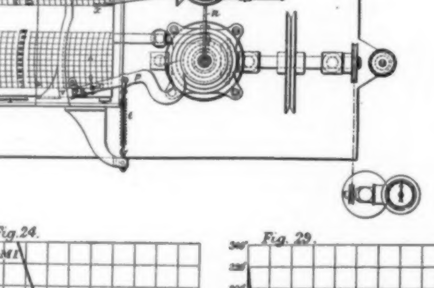
The part of the machine in which the frictional tests are carried out is shown in Fig. 4, which is a part-sectional elevation. The two parts R and T form the two friction members. They have annular surfaces, between which lubricating oil or fat is fed in any suitable manner, such as by raising the upper member R and supplying oil between the surfaces, or by providing an oil pan on R from which oil may be fed to the surface through a small hole. The lower friction-member T is mounted on a vertical spindle driven by the bevel-wheels W and V from the pulley, as shown, the source of power in this case being a small motor which may be seen in Fig. 1, but any convenient form of drive may be adopted. Means are also provided whereby the spindle U can be made to rotate a short distance one way or the other by means of the mechanism, shown in Fig. 6 and in the background in Fig. 1, which is driven by the rope-pulley Z. From this pulley reciprocating motion is given to the crosshead a, which motion is transmitted to the end of a lever keyed on the spindle U, Fig. 4, but not shown in that figure. The friction members R and T are surrounded by a casing b, in which there are the steam inlet and outlet connections c and d. The upper friction member is carried on a vertical rod e which passes through a gland on the casing. This rod has an enlarged part on it at f, forming a piston, and a small pipe connects the steam space in the casing b with a small annular space g above the piston, as shown in Fig. 4. This is done in order that the pressure on both sides of the piston may be equal. The rod e is loaded by means of the lever h held down at one end by the spring balance, by means of which a varying load can be put upon the friction members. A jacket j surrounds the casing b, and means are provided for cooling the lower friction member T with water, if desired, for which purpose a pipe k leads to the interior of the casing b, and there is an overflow pipe which is not shown in our illustration.

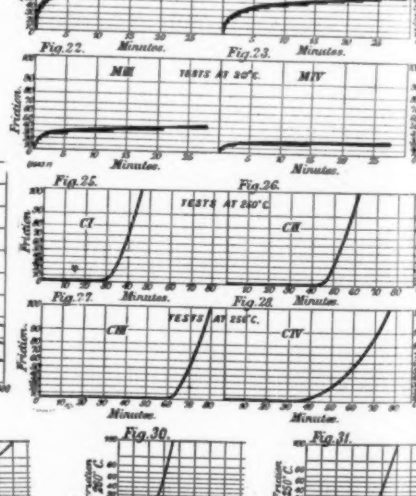
The pipe k may, if desired, be used as a run-off pipe for condensed steam. When required, the casing b can be heated by means of the Bunsen burner l. The instrument is also fitted with a recording apparatus, which is shown in Fig. 5, on which there is a spiral spring thermostat m, the thermometer-tube n leading therefrom through the rod e to the friction members. The rod e is connected by means of a lever p with the pencil r, which works over the recording arrangement s, Figs. 4 and 5. In connection with the lever p is a spring t, which is put in tension by the movement of the lever. On the lever p there is also a pawl u, which engages with a toothed rack v, and prevents a return movement of the lever p until released by the disengagement of the pawl. The thermometer is connected with a pencil x carried on the lever w, which works over a recording device y. The strips on which the records are so marked are moved simultaneously and uniformly by mechanism, as shown; and, if desired, the records can be taken on one broad strip. The strip is fed from the roller z, and passes over the guide-rollers a^1 and b^1 and the winding up roller c^1, which is driven by worm-gearing, as shown. When the spindle U has a to-and-fro motion given to it, the spindle d^1 (Figs. 4 and 7) is shifted sideways so that the worm-wheel e^1 is out of engagement with the worm on the spindle U (see Fig. 4), while the worm-wheel f^1 comes into engagement with the worm g^1 on the driving spindle of the rope-pulley Z (Fig. 6), for which purpose the spindle d^1 is adjustably mounted in bearings. The operation of the mechanism is as follows: When the spindle X is put in gear with the spindle U, the testing of the lubricating oil between the friction members R and T can take place under the continuous rotation of the member T. Owing to friction, the member R is caused to rotate with the member T, and through the lever p acting against the spring t (Fig. 5) the recording-pencil r describes a curve on the recording strip. The friction member R will, of course, be rotated more or less with the member T according to the nature of the lubricating oil or fat being tested. If the spindle d^1 is moved as before described, and the rope-pulley Z be put in gear with the spindle U, an oscillatory movement is given to the friction member T, through the mechanism shown in Fig. 6, and the properties of the oil under test can be ascertained under this motion, the member R being rotated, more or less, according to the friction, the return movement of R being prevented by the pawl u being allowed to engage with the rack v. By this means the lubricant can, if desired, be tested both for rotary motion and for oscillatory motion, and the pressure can be varied by means of the spring balance. In addition to this, steam pressure can be applied during the test, the steam being inclosed in the casing b or passed through the same. Tests may also be carried out while the lower member T is cooled by water admitted by the tube k, the water running off by the tube c. This method is adopted if tests are made at a constant temperature.

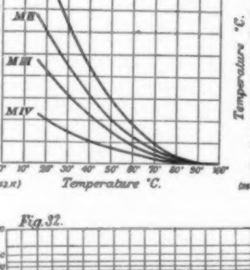
The frictional surfaces of R and T are made in dif-

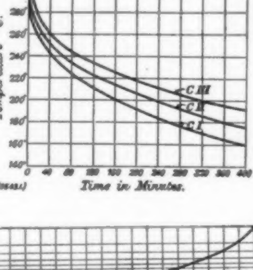


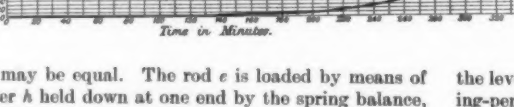


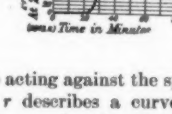


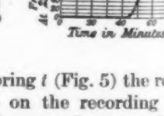












ferent ways, as shown in Figs. 8 to 19. The first three of these show an arrangement similar to that of ring-lubrication bearings, the lower plate having two rings—one on the outer and one on the inner side. By this means a vessel for the reception of a comparatively large quantity of oil is formed around the frictional surfaces. The upper disk has on it a number of incisions with rounded edges, so as to facilitate the free flow of oil to the point at which it is tested. Figs. 11, 12, and 13 show the surface arrangement of other disks, by means of which, and by a drop-feed lubricator, it may be ascertained how many drops of oil are required for proper lubrication under the conditions of the test, the frictional surfaces being kept in a normal condition as regards both friction and temperature. Figs. 14, 15, and 16 show the arrangement for tests of solid lubricants. Figs. 17, 18, and 19 show the arrangement for testing cylinder oils. In this case the lower plate is furnished with incisions, which serve to remove superfluous oil, thus insuring that only just sufficient oil is used for the purpose of the test.

Some "value curves" for machinery-oil and cylinder-oils are shown in Figs. 20 to 32. In these Fig. 20 is the curve of a machinery oil, well adapted for slow-running heavily-loaded bearings. Fig. 21 is well suited for machine and shaft bearings. As may be seen from the curves, the oil represented by Fig. 20 requires more power than that represented by Fig. 21 to enable it to overcome the friction at 70 deg. Fahr. (20 deg. Cent.), the proportion being 88 to 60. The oil represented by Fig. 22 is well adapted for lightly-loaded bearings, and Fig. 23 shows an oil well suited for high-speed bearings. The proportion of power required by oils (Figs. 22 and 23) to overcome the friction, as compared with oil (Fig. 20) are as 42 to 88 and 20 to 88, respectively, at a temperature of 70 degrees Fahr. (20 degrees Centigrade).

Fig. 24 shows the comparative values of the four oils just mentioned (Figs. 20 to 23). The oils were examined at temperatures of 16 deg. Cent., 20 deg. Cent., 30 deg. Cent., 40 deg. Cent., 50 deg. Cent., 60 deg. Cent., 70 deg. Cent., 80 deg. Cent., 90 deg. Cent., and 100 deg. Cent., under the same conditions and modes of operation at each temperature, and the different values obtained have been marked in the respective divisions of the chart, and lines drawn through these give the curves. The horizontal figures on the chart indicate the different temperatures of the tests in degrees Centigrade, and the vertical figures 0 to 100, the proportional amount of friction, that is, the power required to work the frictional parts of the machine with the respective oils. Further, the divisions 0 to 100 indicate the comparative amount of pressure which the different oils can withstand at the respective temperatures. If any points be taken in the same vertical in the curves of the different oils, they may be compared with similar points in the curves (Figs. 20 to 23). The curves show that the values of the oils change proportionally to the temperature of the frictional surfaces. From these combined results can be established frictional standards for each of the four oils at all temperatures. The curves also indicate the proportionate thickness of the layer of each oil required at a given temperature, and, further, the comparative values of the oils in relation to their capacity for withstanding different degrees of heat. Similar tests can be made with solid lubricants by substituting special disks in place of the ones used in testing machinery oils.

Figs. 25 to 28 are the curves for four different grades of cylinder oils, which were subject to a constant temperature of 482 deg. Fahr. (250 deg. Cent.). The first curve shows a good lubricating property for 30 minutes. After 38 minutes the oil was consumed and the friction surfaces were dry. The second oil (Fig. 26) was a better lubricant than the first, as it lasted for 45 minutes, and was consumed after 57 minutes. The third oil (Fig. 27) gave the best results, as its lubricating properties lasted 62 minutes, and it was consumed in 75 minutes, while the last oil (Fig. 28) lubricated for 35 minutes in a good way, after which it thickened slowly and the surfaces were dry after 75 minutes. Of these cylinder oils, the third one was the best, having great durability and leaving no residue, while the last one left a considerable quantity. Fig. 29 shows the comparative values of three of these oils at 250 deg. Cent. The diagrams show that heat has a considerable influence on viscosity. The tests of a cylinder oil were taken at 260 deg. Cent., 250 deg. Cent., 200 deg. Cent., and it will be seen from Figs. 30, 31, and 32 that the effect of temperature is considerable.

It is not possible here to give further examples, but we think we have shown enough to illustrate what the machine is capable of as a means of testing the quality of oils. It is also valuable for matching cylinder oils and all machinery oils and greases.

Use of Fuels in the United States Navy*

By H. I. Cone

The fuels used in the Navy are coal, fuel oil, and gasoline.

Coal must have certain characteristics to make it suitable for naval use.

One of the most important strategical requirements of a warship is her ability to steam great distances without recoaling. Another is her ability, in time of need, to make high speeds. As both bunker capacity and boiler power are limited by other features of design, it follows that the coal must have the greatest thermal efficiency obtainable in connection with the other necessary characteristics.

Considerations of weight and space impose certain restrictions upon boiler design. In naval boilers the ratio between cubic foot of combustion space and pounds of fuel consumed per minute is necessarily much less than in other types. The effect may be most readily grasped if expressed in terms of the length of time that a given volume of the gases generated by the burning coal remains in the furnace. The following figures are quoted from a report of the Bureau of Mines of the Interior Department:

	Fuel per hr. per sq. ft. of grate.	Time each cu. ft. of gas stays in furnace.
Torpedo Boat Boiler	40 lbs.	0.077 seconds
Modern Locomotive	60 lbs.	0.17 seconds
Stationary (Heine)	25 lbs.	0.58 seconds

It is apparent from the foregoing that naval coal must be as low as possible in volatile content. This second characteristic is as important as the first, for it matters little if the coal is high in B.T.U.S. but is of such chemical composition that too many of them group the smoke pipe in the form of unconsumed gases and tarry vapors. But it is usually difficult to get a coal producer to admit the inferiority of his product for naval use when a chemist has certified that laboratory analysis shows it to contain as many thermal units as coal that the Navy is buying, but to run perhaps 20 per cent less in fixed carbon.

High volatile coals are usually very smoky in naval boilers. Smoke not only reveals the location of the fleet but might fatally interfere with accuracy of gunfire.

Amount of ash is a characteristic affecting not only the ultimate thermal efficiency to a greater degree than laboratory analyses may indicate, but also the amount of labor involved in disposing of the refuse. Exhaustion of the firemen may be the determining factor in battle.

Amount and nature of clinkers has the same bearing as ash. Some coals suitable in other respects fuse to the grates to an extent which soon shuts off the air supply; their removal is the most exhausting work a fireman has to do.

Coal should coke readily to avoid loss through the grates as fires have to be "worked" vigorously when steaming at high powers, and during the frequent, sudden and great changes in speed incident to fleet maneuvers.

The final characteristic is cost. It is fortunate for the Navy that the coals which best fulfill all the other characteristics are usually the cheapest in dollars and cents per horse-power developed.

Extended experience under service conditions and numerous special tests show that the semi-bituminous coal from the great fields in southeastern West Virginia, western Maryland and southern Pennsylvania are the American coals which best fulfill these requirements. They comprise the great bulk of all the coal used in our Navy, both at home and on foreign stations. In special cases where it is desirable or necessary for ships remote from Government colliers or Government coal piles to purchase coal, Admiralty Welsh is usually selected if American coal of the required kind is not obtainable at lesser cost. Welsh coal is not different from ours in its performance in naval boilers, but is much more likely to cause trouble from explosive gases in the bunkers.

Coal equal or superior to the American coals now used is thought to exist in great quantities in Alaska, but it seems questionable whether the fields will be developed sufficiently to supply even a part of the Navy's needs before the time when most of the coal burning ships will have been written off the Navy's books.

The advantages of oil as compared with coal are:

An evaporation per pound of fuel in the ratio of about 14 to 9, and per square foot of heating surface in about the ration of 10 to 8.

Fuel can be taken aboard more rapidly without manual labor, and without interruption to the routine of the ship. The problem of fueling at sea is solved.

Steam for full power can be maintained as readily as for low power. A vessel burning oil is capable of runs at full speed limited in duration only by the supply of fuel. There is no reduction in speed due to dirty fires or to difficulty in trimming coal from remote bunkers, or to exhaustion of the fireroom force.

There are no cinders and the amount of smoke can be controlled.

A considerable reduction in *personnel* is possible.

The weight and space required for boilers is reduced. First, by the reduction in heating surface required, and second, by the shortening of firerooms. Consequent on the reduction in heating surface is a decrease in weight and cost of boilers.

Coal and ash handling gear is eliminated. This renders unnecessary the piercing of the hull for coal trunks and discharges from the ash expellers or ash ejectors.

The stowage and handling of oil is much easier than of coal and will result in a much cleaner ship with consequent increase in time available for drills.

The mechanical supply of fuel to the boilers gives a prompt and delicate control of the steam supply, permitting more sudden changes in speed than with coal which is a tactical advantage.

The nature of fuel oil permits utilization of remote portions of the ship and of constricted spaces for its stowage.

These advantages have long been recognized by the Navy and there have been experiments with liquid fuel dating back as far as 1867. All these experiments have confirmed our belief in the considerable military advantages which will accrue from its use, but until recently it has been impracticable to use it extensively on account of the uncertainty as to the adequacy of its supply and the sufficiency of its distribution among the seaports of the world. We are now assured, however, as regards the supply, that there is sufficient oil on the public lands of the State of California alone to supply all probable naval demands for one hundred years should oil be burned to the exclusion of coal, and of course there is considerable oil in other portions of U. S. territory. The question as to the distribution of oil among the ports from which fuel might be required by our vessels in time of war is one that is well within our power to solve, as from its nature the oil can be transported and stored more easily than can coal. Indeed for the transport of oil in time of war we are already better provided than for coal, there being a large number of tank steamers flying the American flag. Oil is therefore certain rapidly to replace coal as a fuel for Navy purposes.

Since 1907 all torpedo boat destroyers contracted for, of which there are 29, burn oil exclusively, and the battleships "Delaware," "North Dakota," "Florida," "Utah," "Wyoming," "Arkansas," "Texas" and "New York," contracted for during this period, are fitted to burn oil as auxiliary to coal, each of these vessels carrying about 400 tons of the liquid fuel, to be burned at full power after the coal fires become dirty, or when it becomes difficult to trim coal from the bunkers into the firerooms. In the case of these battleships the advantages of the oil have so appealed to the *personnel* that oil alone is burned to a great extent in port, and to some extent while cruising, although the installation of the oil-burning equipment did not contemplates these uses.

The "Nevada" and "Oklahoma," the two battleships which have recently been contracted for, will burn oil exclusively. This is perhaps the most radical development in naval engineering since the advent of the turbine. It has permitted in the case of these vessels a reduction in boiler weights, which has made possible the use of heavier armor than has hitherto been employed. The reduction in length of boiler compartments has permitted the grouping of all boilers under one smoke pipe, which course clears the upper deck considerably and permits more extensive arcs of fire for the turrets.

Aside from the use of oil as fuel under steam boilers, it now seems probable that within comparatively few years oil used in internal combustion engines will furnish the principle fuel for all naval vessels. This is in consequence of the recent remarkable development of heavy oil engines of the Diesel type in Europe. Hitherto, oil engines have not merited much consideration for large naval vessels on account of the limited power that could be developed in a single cylinder. An installation of any considerable power required a multiplicity of cylinders. Now, however, we are credibly informed that 1,000 horse-power has been developed in a cylinder about 33 inches in diameter with a 40-inch stroke, at 150 revolutions per minute in a 2-cycle marine type readily reversible engine. This engine has a speed control that is satisfactory, and an economy of fuel consumption probably twice that of a steam engine.

In the U. S. Navy heavy oil engines built or so far projected are limited to a number of submarine vessels and to mother ships for submarines. The former develop 1,200 horse-power, distributed between two shafts, the latter 900 horse-power on one shaft.

Gasoline is used as fuel for all of our earlier submarines and for a large number of small power boats carried by warships. Its use is likely to be discontinued entirely as soon as suitable heavy oil motors for the small power boats are developed. As stated above heavy oil engines are already supplanting gasoline engines in submarines.

*Paper read before the Eighth International Congress of Applied Chemistry.

NEW BOOKS, ETC.

Reconstruction and Union. 1865-1912. By Paul Leland Haworth, Ph.D. New York: Henry Holt & Co., 1912. 16mo.; 255 pp. Price, 50 cents net.

Prof. Haworth has a trick of writing history with journalistic crispness and vigor, and the most exacting reader could hardly call his story of reconstruction dull. He really transmits a very sharp impression of actual conditions at the close of the war, of the efforts made to deal with the problems left in the wake of that war, and of subsequent puzzles and responsibilities arising from the war with Spain and the acquisition of the Philippines. He has also something to say of the "golden age of materialism," and he outlines the revolt against plutocracy which brings us to the present year of the Republic.

The English Language. By Logan Pearsall Smith, M.A. New York: Henry Holt & Co., 1912. 16mo.; 256 pp. Price, 50 cents net.

To most people, even to educated people, their own language is something that is taken for granted, like the possession of a heart, lungs, and other bodily organs. This is not a desirable condition of affairs, and those who take the trouble to read "The English Language" may no longer be criticized under this head. It tells us of the origins and elements of the language we speak, details the processes of word-making, and considers the history of the mother-tongue under three periods—the early, the middle ages, and the modern. There is an interesting application of the knowledge of the age of words to detecting forgeries of old manuscripts. Condensed as the work is, it makes the reader conversant with the general and historic facts of philology and, for those who would go further in the fascinating study, a bibliography of more advanced works is appended.

Heredity and Eugenics. A Course of Lectures Summarizing Recent Advances in Knowledge in Variation, Heredity, and Evolution and its Relation to Plant, Animal and Human Improvement and Welfare. By William Ernest Castle, John Merle Coulter, Charles Benedict Davenport, Edward Murray East, and William Lawrence Tower, Chicago: The University of Chicago Press, 1912. 8vo.; 315 pp.

The lectures of which this book is composed were given at the University of Chicago in 1911, under the auspices of the Biological Department. The purpose was to present the recent developments of knowledge in reference to variation, heredity and evolution, and the application of this new knowledge to plant, animal and human development and improvement. Anyone at all familiar with the subject must recognize that the men who delivered these lectures stand foremost among American students of evolution and heredity. Couched, on the whole, in an easily understood style, the lectures in book form will appeal to a wide audience interested in the progress of genetics as a matter of information as well as of study.

Handbuch fuer Herr und Flotte. Berlin: Deutsches Verlagshaus Bong & Co., 1912. 32 pp.; illustrated.

The present installments of this admirable military and naval encyclopedia (Nos. 45, 46 and 47) continue the discussion of the wars of modern times. American readers will find a particular interest in the review of the principal engagements of the civil war.

The Chemistry of the Rubber Industry. By Harold E. Potts, M.Sc. New York: D. Van Nostrand Company, 1912. 8vo.; 153 pp. Price, $2 net.

The work is a text-book and guide especially designed for employees who, with but too slight acquaintance with chemistry to receive much help from such advanced and exhaustive volumes as deal with the details of the separate industries, yet wish to acquire for themselves knowledge that otherwise could come only through busy senior members of the staff by a slow process of questioning, observation, and absorption. In other words it is sought to bridge the gap between pure chemistry and manufacturing practice, and to "exhibit the points of contact between Chemistry and the Industry." A chapter on colloidal chemistry begins the book; the production and manufacture of rubber are considered in their relations to chemical routine and research; and the most important analytical processes are thoroughly explained. The author has extended some very real assistance to young chemists and technologists whose activities come within the scope of his subject.

The Mechanistic Conception of Life. Biological Essays by Jacques Loeb, M.D., Ph.D., S.D., Member of the Rockefeller Institute for Medical Research. Chicago: The University of Chicago Press, 1912. Price, $1.65.

The essays of which this volume is composed comprise papers which have appeared in various scientific periodicals and which have been read before learned societies. Their titles are the following: The Mechanistic Conception of Life; The Significance of Tropisms for Psychology; Some Fundamental Facts and Conceptions Concerning the Comparative Physiology of the Central Nervous System; Pattern Adaptation of Fishes and the Mechanism of Vision; On some Facts and Principles of Physiological Morphology; On the Nature of the Process of Fertilization; On the Nature of Formative Stimulation (Artificial Parthenogenesis); The Prevention of the Death of the Egg Through the Act of Fertilization; The Role of Salts in the Preservation of Life; The Experimental Study of the Influence of Environment on Animals. In these essays Prof. Loeb enunciates no new ideas. He reiterates the conclusions which he has drawn in the past from remarkable experiments made chiefly in the field of artificial parthenogenesis and tropisms. The phenomena of life as Prof. Loeb seeks to show, are to be explained almost if not entirely on purely chemical grounds. For such rather meaningless terms as "instinct" on which the older biologists relied in order to explain the movements of insects suddenly exposed to light, he substitutes positive and negative heliotropism. The phenomena of fertilization, likewise, he finds can be readily explained by chemistry on the basis of experiments.

Smoke. A Study of Town Air. By Julius B. Cohen, Ph.D., B.Sc., F.R.S., and Arthur G. Ruston, B.A., B.Sc. New York: Longmans, Green & Co., 1912. 8vo.; 88 pp. Price, $1.40 net.

"Smoke" constitutes a real study of a real problem, and not a mere loose discussion of a widespread nuisance and menace. The work issues from Leeds, England, and the frontispiece is a most impressive view of the industrial section of that city, showing its many belching stacks and fuming chimney-pots. Smoke is deleterious in three ways—it injures vegetation, it disintegrates stonework, and it is detrimental to health. These heads ignore its condemnation on purely æsthetic grounds. The work is essentially a collection of facts and figures, drawn from observations extending over a period of twenty years.

Matter and Energy. By Frederick Soddy, M.A., F.R.S. New York: Henry Holt & Co., 1912. 16mo.; 253 pp. Price, 50 cents net.

The Principles of Physiology. By John Gray McKendrick, M.D., LL.D., F.R.S. New York: Henry Holt & Co., 1912. 16mo.; 256 pp. Price, 50 cents.

Psychology. The Study of Behavior. By William McDougall, M.B., F.R.S. New York: Henry Holt & Co., 1912. 16mo.; 256 pp. Price, 50 cents net.

These three little volumes of the Home University Library are excellent text-books for the general reader in the subjects of which they treat. "Matter and Energy" gives a periodic table of the elements and sketches the history of physical science. The atom, heat and the kinetic theory of matter, chemical energy and radioactivity, are all considered in separate divisions of the work, together with other phases of this fundamental science. In "The Principles of Physiology," the characteristics of living organisms, the origin and development of the individual, and the processes and phenomena of life are laid before us in simple language, while "Psychology" goes a step further and seeks to familiarize us with the known facts of consciousness, the structure of the mind, and the powers of purposive control which animals and men manifest in the everyday actions of their lives. The chapter on abnormal psychology gives a glimpse into the problems of diseased mentality—of hysteria, the dual personality, and the phenomena which are popularly connected with spiritualism. The book is exceptionally well-written, and should prove for non-scientific readers an open door to further investigation in a most fascinating field.

Identification of the Economic Woods of the United States. By Samuel J. Record, Assistant Professor of Forest Products, Yale Forest School, 8 vo.; vii, 117 pp.; New York; John Wiley & Sons, 1912. Price, $1.25 net.

This book is intended for the use of the teacher and student of forestry as a guide in the forest school laboratories and as a work of reference. It is a much needed work and will be eagerly welcomed by many who are interested in our native commercial woods. The book is divided into two parts. Part I deals with the structural and physical properties of wood, and Part II consists of an analytical key which is intended to aid the student and wood user to distinguish between our native commercial woods by their gross and minute characters. The selection of the material presented in Part I of the work has been made with care, and it is believed that it will not only tend to bring about a uniformity in the nomenclature of the wood elements but also establish a standard as to what should be taught in forest schools. The discussions of the vessels, tracheids, wood fibers, wood-parenchyma fibers, etc., will appeal to those who have means to examine such structures under the compound microscope, a correct knowledge of which is essential to technical men dealing with the mechanical and physical characteristics of woods as an aid in their deductions and conclusions. The author has been obliged, perhaps of necessity, to content himself with a brief statement of facts relative to the physical properties of wood. It appears that certain portions might have received a fuller discussion. The relation of structure to mechanical properties of wood is a phase of the subject which was entirely omitted by the author.

Part II consists of an analytical key in which the author classifies the woods according to marks of resemblance and difference; this is entirely new and of very general interest. In this key the author gives a concise description of each wood, using both gross and minute characters helpful in recognizing the different woods in the form of lumber. This portion of the book will be of great service to the lumberman and the wood users. In some cases no attempt has been made to distinguish between all of the species of the same genus, as for instance, the oaks and pines. Perhaps, this is the only practical course where the main consideration is the character of the wood as represented in part of the group, namely, white oaks and red oaks, rather than minute distinguishing characters of the individual species which are in many cases at present poorly understood and still more poorly defined. The value of the key is greatly increased by the addition of numerous illustrations of transverse and longitudinal sections of wood.

The work closes with a long list of publications dealing with the structure and use of commercial woods. This reference list is designed to be of service to those who wish to refer to a more complete discussion of certain woods.

Earth Features and Their Meaning. An Introduction to Geology for the Student and the General Reader. By William Herbert Hobbs. New York: The Macmillan Company, 1912. 8vo.; 506 pp. Price, $3 net.

There has been room for a considerable time for a thoroughly modern book on geology, which should contain the modern concepts of the science conveyed in easily understood terms and well illustrated. The author seems to have produlced an ideal book in many ways. It is finely illustrated by 493 maps, plans, and illustrations, the most interesting of which are those which show the development of topographical maps and graphic representation of physical phenomena by simple means. The study of geology is an excellent discipline for the mind and is of service even to those who never put the knowledge to practical use. Far more than in former years the American travels afar by car or steamship and the earth's surface features in all their manifold diversity are thus one after the other unrolled before him. The thousands who each year cross the Atlantic to roam through European countries, prepare themselves by historical, literary, and artistic studies to derive exquisite pleasure from their visit. Yet the Channel coast, the gorge of the Rhine, the glaciers of Switzerland, and the wild scenery of Norway or Scotland, have each their fascinating story to tell of a history far more remote and varied. To read this history, the runic character in which it is written must first of all be mastered; for in every landscape there are strong individual lines of character, such as the pen artist would skillfully extract from an outline sketch.

The object of the present volume is to enable the student to himself pick out in each landscape these more significant lines, and thus read directly from nature. Regarded as a text book of geology, the present volume offers some departures from existing examples, but this does not interfere with its use by the general reader, who has real need for a book which may be read intelligently by all who are in any way interested in science in general. The chapters deal with a Compilation of Earth History, The Figure of the Earth, The Nature of the Materials, The Contortions of the Strata, The Fracture Superstructure, Earth Movements, The Rise of Molton Rock, The Attack of the Water, The Life History of Rivers, The Travels of Underground Waters, The Forms Carved and Molded by Waves, Coast Records of the Rise or Fall of the Land, The Glaciers of Mountain and Continent, Land Sculpture, Lake Basins, Origin and Forms of Mountains, etc.

There is also an excellent appendix on the quick determination of the common minerals. It is an excellent book on a very important subject.

Illinois. Indiana. New Jersey. New York. Ohio. Pennsylvania. New York: Rand, McNally & Co., 1912. Price each, 25 cents.

For the benefit of the few who may be unacquainted with these inexpensive but accurate and informing little geographical guides, we may say that each consists of a folding map in paper covers, accompanied by such information as travelers and shippers are most in need of. The map locates the nearest mailing point of all local places; gives the money-order post-offices, telegraph companies, and express companies, and shows in detail the railroad systems. The map is indexed, so that any town, county, lake, or river may readily be found. All the States and Canada are covered by these publications, and the plates, indexes, and population figures are thoroughly up-to-date in every particular.

The Design of Mine Structures. By Milo S. Ketchum, C. E. New York: McGraw-Hill Book Company, 1912. 8vo.; 459 pp.; illustrated. Price, $4 net.

Head works design naturally occupies the position of chief importance in such a work as this, followed by a discussion of hoisting methods, head frame stresses and head frame and coal tipple designs. But mine buildings are not neglected, and a third division deals with details of design and cost. There are also appendices which take up specifications for steel structures, steel frame buildings, head frames and coal tipples; specifications for timber mine structures; and reinforced concrete design. The description of machinery is quite properly limited to its operation in so far as mine structures are affected. Folding plans of actual frames, ore bins, rock houses and coal tipples add materially to the value of the work, which shows the same careful arrangement, handling, and development of detail that we have noted in other works by the same author.

Heredity and Society. By W. C. D. Whetham, F.R.S., and Catherine D. Whetham, his wife. London and New York: Longmans, Green & Co. Pp. VIII plus 190.

Mr. and Mrs. Whetham have performed many a useful service by exposing in a popular way the perils that confront human society by permitting bad human protoplasm to propagate itself unchecked. In a splendid chapter entitled "Heredity and Politics" the result of some of the more recent humanitarian legislation is considered. The authors point out, and very forcibly to our mind, that most of the ills of society can be cured by checking the propagation of the unfit.

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